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THE BELLEFONTAINE BRIDGE.

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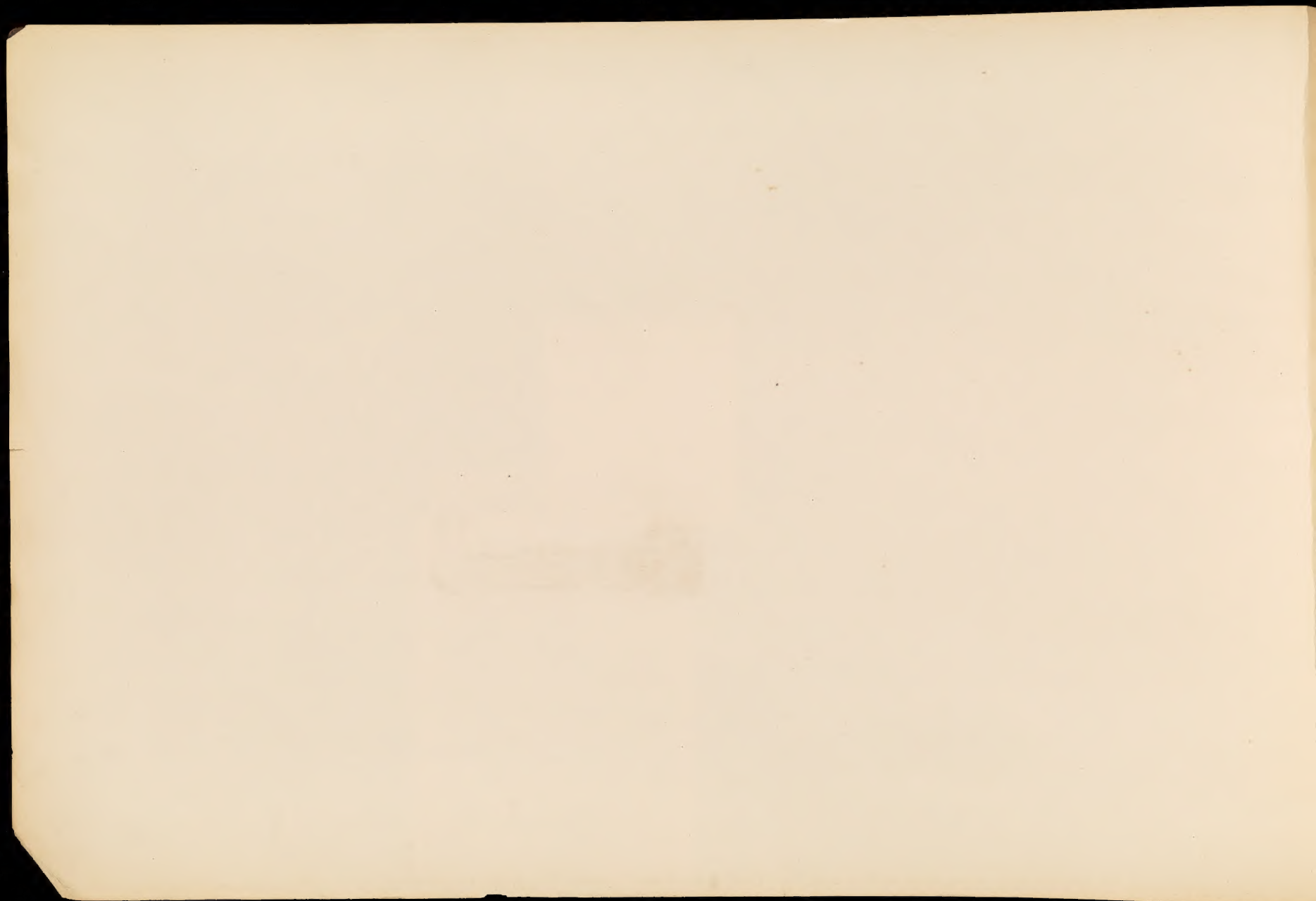
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GEO. S. MORISON,

Chief Engineer.

1742 Monastnock Block,
Chicago.

THE BELLEFONTAINE BRIDGE.

A REPORT

TO CHARLES E. PERKINS, PRESIDENT OF THE CHICAGO, BURLINGTON & QUINCY RAILROAD,

BY

GEORGE S. MORISON, CHIEF ENGINEER OF THE BELLEFONTAINE BRIDGE.

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CHICAGO, December 31, 1894.

CHARLES E. PERKINS, Esq.,
President Chicago, Burlington & Quincy R. R. Company.

DEAR SIR:—

I submit the following Final Report in relation to the Bridge across the Missouri River at Bellefontaine Bluffs, Missouri.

Yours truly,

GEORGE S. MORISON,
Chief Engineer.

THE BELLEFONTAINE BRIDGE.

I.

PRELIMINARY NARRATIVE.

The Bellefontaine Bridge is on the main line of the St. Louis Extension of the St. Louis, Keokuk & Northwestern R. R., one of the proprietary lines of the Chicago, Burlington & Quincy R. R. It is built under authority of an Act of Congress, approved February 17th, 1888, which charter is printed in Appendix B.

The selection of terminals for the St. Louis, Keokuk & Northwestern R. R. in the City of St. Louis, and the location of a line by which that railroad might be extended to the City of St. Louis, was placed by you in my hands in the early part of 1887. This extension involved a bridge across the Missouri River. An examination of the country north of St. Louis and of the Missouri River convinced me very early that the extension ought to be built through the bottom land between the Mississippi and Missouri Rivers, crossing the Missouri River so near the mouth that a low grade line could be built from the bridge to the city. The importance of a line of this kind was further emphasized from the fact that the place in which it was decided to purchase terminal yards was in the northern part of the city adjoining the Mississippi River. On the 19th of May, 1887, I examined the bluff from the

northern limits of the city to a point called Jamestown Landing, from the fact that many years ago the cargo of the wrecked steamer JAMESTOWN had been landed there, and at that time selected the location on which the bridge has been built, as the best point to cross the river. This location is 8.2 miles from the mouth of the river according to the maps published by the Missouri River Commission. It is almost immediately opposite the City of Alton and only 4½ miles from that city. It was evident to me at the time, that if a bridge was also built across the Mississippi River at Alton, the Missouri River Bridge could be made to serve as the entrance to St. Louis for railroads from the east as well as from the west. Although your company did not see fit to undertake the construction of both bridges, the Alton Bridge has been built by another interest, simultaneously with the construction of the Bellefontaine Bridge.

The purchase of St. Louis terminals was begun in 1887 but was conducted secretly until May 10th, 1889, when deeds to the company were first placed on record in St. Louis. The actual location of the line was made in 1889 and 1890. In April, 1889, a party was sent to the site selected for the bridge, and borings were made to ascertain the depth to rock; these borings found rock at depths considerably greater than had been anticipated.

The plans for the structure were submitted to the Secretary of War and approved by a formal contract with the War Department dated December 21st, 1889, this contract being printed in Appendix B.

Actual construction was not begun till 1892, when, on the 19th of February, you authorized me to proceed with the construction of the bridge over the Missouri River.

Mr. B. L. Crosby was appointed Resident Engineer of the work, and on the 1st of July, 1892, he was relieved of the work of which he had been in charge in St. Louis, and his headquarters were established at the bridge.

As the situation was an inaccessible one and remote from any town, it became necessary to establish a camp at the site of the bridge and to

construct buildings for use. The first actual work done in preparation was on April 7th, 1892, when a force began clearing timber from the right of way. On April 19th the building for the engineer's office was begun.

The steamer JOHN BERTRAM, with a full outfit of pneumatic machinery, which had been used at the Rulo, Nebraska City and Memphis Bridges, as well as for some repair work at the pivot pier of the Kansas City Bridge, was brought to the bridge site on the 7th day of May.

Eighteen hundred and ninety-two was a year of high water; the lower Missouri River as well as the Mississippi River at St. Louis were higher than at any time since 1858. The slope of the river opposite the City of St. Louis was, however, somewhat abnormal, and it is probable that the river at the site of the Bellefontaine Bridge was higher than it has been at any time since 1844. On the 18th day of May it reached elevation 115.1; the zero being a datum plane 100 feet below the St. Louis City directrix, to which datum all levels on the work were referred. This high water prevented any considerable amount of work being done during the first half of the year.

The first actual work done was on the 4th of July, 1892, when the excavation at the site for Pier I was begun. The first work on the river foundations was begun on the 13th of July, when the first timber was framed for one of the caissons.

The work of construction went on continuously without interruption till the completion of the work. The system on which the work was conducted was the same that had been adopted on other large bridges built under my direction. The foundations were put in by a force working under the immediate direction of the Resident Engineer. The masonry and superstructure were let by contract.

The contract for the masonry was let to the firm of Christie & Lowe, Mr. George A. Lederle being the resident partner, the contract being dated March 28th, 1892. The contract for superstructure of the bridge proper was let to the New Jersey Steel & Iron Company of

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Trenton, N. J., the contract being dated June 18th, 1892. The contract for the steel viaduct at the north end was let to A. & P. Roberts & Company of Pencoyd, Pa., their contract being dated December 14th, 1892. On the 9th day of September, 1893, a contract was made with Mr. William Baird for the erection of the superstructure of the main bridge. Small contracts for the delivery of special materials were made from time to time, but there were no other important contracts.

The superstructure was erected and a track laid across the bridge so that the first train crossed on December 27th, 1893. No formal opening took place. The first regular time table went into effect March 4th, 1894, at which time the bridge was put in regular service as a double track structure.

II.

GENERAL DESCRIPTION.

The Bellefontaine Bridge is a double-track railroad bridge. It consists of four through spans, each 440 feet long between centers of end pins, resting on one masonry abutment and four masonry piers. At the north end of the bridge there is an iron viaduct 849.83 feet long, consisting of 28 spans, resting on brick piers with pile foundations. The total length of the permanent structure from the face of the back wall of the abutment to the end of the iron viaduct is 2 630.77 feet. The four main spans of the bridge are built on a vertical curve corresponding to the camber of the trusses. The viaduct descends from the bridge northward with a grade of 0.5 per cent.

As the south abutment is founded on rock above low water, and

the bluff rises rapidly from this rock, there is virtually no south approach.

The north approach consists of 2960 feet of temporary timber trestle, which is built on the continuation of the grade on the iron viaduct; beyond this trestle is a solid earth embankment built to the same grade. The grade line south of the river was so laid that enough material would be taken from the cut through the bluffs to fill the entire trestle, the track being first laid on a temporary location.

The bridge and north approach are on a single straight line. 6 984 feet from the north end of the viaduct, this tangent intersects two other tangents, one leading westward and forming the main line of the St. Louis, Keokuk & Northwestern R. R., and the other leading to the Alton Bridge. The bridge and approaches may properly be considered as extending from the south side of the abutment to the foot of the grade on each of the two diverging lines.

The location of the bridge is shown on Plate 1. The general character of the bridge and the profile of the approach are given on Plate 2. The piers were numbered from the south northward, the south abutment being Pier I, the north pier, Pier V. This same numbering, designated, however, by Arabic numerals, was extended to the viaduct piers.

III.

SUBSTRUCTURE.

The substructure of the bridge proper consists of one masonry abutment and four masonry piers. The abutment is at the south end and is designated as Pier I. The four masonry piers are designated as

Piers II, III, IV and V; they are all founded on pneumatic caissons.

The caissons for Piers II, III and IV are all of the same horizontal dimensions, being 70 feet long, 30 feet wide and 16 feet high. They are surmounted by crib work filled with concrete, having the same horizontal dimensions as the caissons, but varying in height with the several piers. The caisson for Pier V is 24 feet wide, 60 feet long and 16 feet high and surmounted by a timber crib of the same character as that of the other piers. In the larger caissons there are four transverse braces of 16 inch square timber in the working chamber and also a longitudinal timber of the same size; in the smaller caisson the longitudinal timber was omitted, and there were only two transverse timbers. The insides of the chambers were lined with three-inch plank and then carefully caulked. The caissons were built of long leaf yellow pine throughout.

Piers II, III and IV are founded on the underlying bed rock. The foundation of Pier V was not carried to rock.

The following table shows the heights of the four piers:

	Bottom of Foundation.	Height of Crib Work.	Height of Caisson and Crib Work.	Elevation bottom of Masonry.
Pier II.	23.47	34.4	40.4	63.87
Pier III.	3.08	43.13	60.95	64.03
Pier IV.	-9.17	56.1	73.9	64.73
Pier V.	9.28	64.0	80.0	80.28

All the caissons, except that for Pier II, were built on launching ways on the north side of the river and launched and towed into place. The caisson for Pier II was built on blocking on the sand bar at the site of the pier.

The plans of the several piers are shown on Plates 3, 4 and 5. The piers are of the same general plan that I have used on other large structures. Piers II, III and IV measure 12 feet thick and 34 feet long between shoulders, under the belting course. Pier V measures 9 feet

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thick and 39 feet long between shoulders under the belting course. Piers II, III and IV are precisely alike in all dimensions above the crib work except that Pier III is 0.45 feet higher than either of the other two, this difference providing for the vertical curve on the bridge.

The Specifications for Masonry are given in Appendix E. The work is built generally of limestone from the quarries near Bedford, Indiana, or at Romona, Indiana, the two stones being so much alike that they cannot be distinguished in the work. The face stone of the fourteen courses in Piers II, III and IV, from elevation 88.0 to the under side of the starling coping, are granite from St. Cloud, Minn.

The floating equipment furnished by the railroad company was as follows:

Steamer JOHN BERTRAM,	390.49 tons
" PAULINE,	60 "
Concrete mixer barge,	30 ft. x 90 ft.
Pile driver and derrick barge,	24 " x 70 "
Pressure men's house barge,	24 " x 64 "
Sounding barge,	16 " x 24 "
One material barge,	30 " x 81 "
Two " "	26 " x 80 "
One " "	24 " x 80 "
One " "	24 " x 70 "

Several other barges of various sizes were chartered during the work.

Besides this the contractors for the masonry had the following floating equipment:

Steamer Geo. L. BASS,	60 tons.
One derrick barge,	40 ft. x 80 ft., with mast 80 ft. high.
One " "	30 " x 80 " " " 50 " "
Four barges	22 " x 80 "

In view of the great depth at which some of the foundation work had to be done, and as there was apprehension of an unhealthy season,

special arrangements were made for the health and comfort of the men. A regular resident physician was engaged and attached to the engineering staff. A supply of drugs and simple surgical tools was provided, and a small hospital was erected. With these special provisions the work was carried through without any unusual trouble.

The launching ways were built of piles and capped. The first two caissons launched were precisely alike, and the order of their use was determined by the condition of the river at the time.

PIER I.

The first work done in construction was the excavation at the site of Pier I on the south bluff. Work, however, was not pressed and was only carried on at such times as forces could be conveniently spared from other parts of the work. The excavation, which was largely in loose rock, was not completed till December 2nd, 1892. The rock was leveled off with concrete and the first stone was set in this abutment on the 31st of May, 1893. The abutment was finally finished June 22nd, 1893.

PIER II.

The cutting edge of the caisson for Pier II was set up on blocking at the site of the pier on the 24th of October, 1892; the caisson was finished on the 5th of November and was lowered on the sand bottom on the 7th of November, 1892. The concrete filling was begun on the 14th of January, 1893. Air pressure was applied on the 19th of January. The concrete filling of the crib work was completed on the 12th of February. The laying of masonry was begun on the 7th of March. Rock was reached on the south side of the pier on March 30th at elevation 29.60. This rock was a solid ledge but sloped off rapidly to the north; the lowest point of the rock was at elevation 21.60, at the northeast corner, there being a difference of eight feet inside the caisson. Blasting was resorted to on March 31st, using rackarock as the explosive, and was continued until April 23rd when

the caisson reached its final elevation of 23.47. The rock was removed from the caisson by the aid of a clay hoist of the same pattern as was used on the Rulo and Memphis Bridges. The rock was cleaned and the sealing of the caisson begun April 25th; the sealing was finished May 3rd.

On the north side the cutting edge did not reach the rock, except for a short distance near the northwest corner, but blocking was put under the shoulder of the cutting edge to support the caisson and the rock entirely cleared off so that the concrete filling reached to the rock throughout; at the northeast corner of the caisson the concrete was carried down more than two feet below the cutting edge.

During the filling of the chamber with concrete, there was a sharp rise in the river, which completely submerged the pier, only the shafts and pipes being kept above water; and they were protected from injury from drift logs, by a bulwark of bags of crushed stone built up on the nose of the pier and extended around the shafts. During the last day or two the water was five feet deep over the masonry of the pier.

The entire pier was finished July 4th, 1893.

PIER III.

The cutting edge of the caisson for Pier III was set up on the launching ways on the 30th of July, 1892, and the caisson was finished and launched on the 20th of August. When this caisson was being built the river fell rapidly and sand bars formed so that there was only from two to five feet of water at the site of the pier, while the caisson drew ten feet. On August 21st the steamer JOHN BERTRAM was moored at the site of the pier and her wheels started to wash out the sand; this was successfully accomplished so that on the 23rd a basin from six to ten feet deep had been washed out. In the meantime barges had been placed on each side of the caisson, and heavy timbers, running across the caisson and barges, were securely bolted to the caisson. On the morning of the 23rd the steamer JOHN BERTRAM was brought back to shore and placed behind the caisson; air connec-

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tions were made with the caisson, and with the help of the steamers PAULINE and GEO. L. BASS, the caisson was towed out till it struck against a submerged bar in the middle of the river. Air was then pumped into the caisson until it was raised enough to pass over the bar; as the caisson was raised by air pressure, blocking was placed on the barges under the heavy timbers bolted across the caisson, to keep it from tipping. The caisson was then towed further till it grounded again near the site of the pier, was again raised until it drew only four feet and a half, was then finally placed, the air pressure released, and the caisson left in position on the sand.

The concrete filling was begun on the 28th of August, and air pressure was applied on the 2nd of September. The concrete filling of the crib work was completed on the 23rd of September. The laying of masonry was begun on the 9th of November. The caisson finally reached the rock at elevation 3.08 on January 3rd, 1893. The rock was cleaned and the sealing of the caisson begun January 5th; the sealing was finished January 11th and the pier was finished May 19th, 1893.

PIER IV.

The cutting edge of the caisson for Pier IV was set up on the launching ways on August 26th, 1892; the caisson was finished and launched on September 20th, on the 24th it was towed into position and securely fastened to four clusters of anchor piles near the four corners; by means of lines leading from these clusters of piles, it was held accurately in position and sunk down to the sand. When the caisson was placed, soundings showed 14 feet of water at the west end and 13 feet at the east end. The work of building up the crib was started that night and continued till the 29th when concreting was begun; at this time the soundings showed about twenty feet of water all around the floating caisson. As the weight of the concrete settled the caisson, the current gradually cut away the sand below the edge; on the morning of the 30th the water all around averaged 23 feet deep,

with 25.5 feet at the northwest corner; in the afternoon the caisson grounded on the south side, and on the morning of the 1st of October it was still aground on the south side, but on the north side the water was 25 feet deep; about 600 bags of sand were thrown in on the up stream end, and on the morning of the 2nd the caisson was aground at this end. Concreting was continued during the 2nd and 3rd, and on the afternoon of the 3rd more sand bags were thrown in along the north side as cutting had begun again there. On the morning of the 4th the air pipes were connected and air pressure applied. On trying to enter the caisson through the air lock, the door of the main shaft below the lock was found to be blocked so that it could only be opened a few inches. Pressure was let off, and a man was lowered into one of the supply shafts, the top put on the shaft, and the air pressure restored; this man entered the caisson and found that a part of a temporary false bottom that had been used in launching had not been removed, and some of the timbers were jammed against the main shaft door; these he cleared away, and the caisson could be entered through the lock. The Resident Engineer entered and found that along the south side and east end the caisson was filled with sand nearly to the roof, while along the north side and west end the sand was below the cutting edge. Some of the false bottom had become wedged under the cross beams, and as weight had been put on the caisson above, it was pressed down till the cross beams supported the greater part of the weight of caisson and concrete. All the cross beams were split, and the vertical posts between them and the roof were either pressed up into the roof or down into the beams; the second cross beam from the down stream end was pressed so that the distance between it and the roof was only 3 feet 4 inches instead of 4 feet, the vertical post at the center was split for its entire length and crushed into the longitudinal beam. Concreting was at once stopped and men began leveling the sand and clearing out under the beams; when this was done, the beam that had been pushed eight inches came back to within three inches of its original position. As soon as everything was cleared the

cracked beams were jacked into place and securely bolted, new posts were put in alongside the damaged posts, and the work went on as usual.

The concrete filling of the crib work was completed on October 23rd. The laying of masonry was begun on October 25th. The caisson finally reached the rock at elevation -9.17 on November 18th. The bed rock in the caisson was covered to a depth of two or three feet with boulders ranging in size from an egg to a barrel; there were too many to attempt to remove without a special hoist, which was not available, and it was decided to work them into the concrete filling of the chamber, cleaning off the bed rock a section at a time and using up the boulders as rapidly as possible. The sealing of the caisson was begun November 20th and finished November 29th, 1892, and the pier was finished April 29th, 1893.

PIER V.

The cutting edge of the caisson for Pier V was set up on the launching ways on November 8th, 1892, the caisson was finished November 25th, launched December 11th, and was placed in position December 16th. The concrete filling was commenced December 16th and the caisson grounded on December 17th. Air pressure was applied on the 21st of December, 1892.

The concrete filling of the crib work was finished February 28th, 1893. The laying of masonry was begun on March 2nd. The caisson reached its final resting place with the cutting edge in sand at elevation 9.26, on March 7th. The sealing of the caisson was begun on that day and finished on March 12th, and the pier was completed May 27th, 1893.

The full details of the five piers are given on Plates 3, 4, 5 and 6. The rate of progress in sinking is illustrated graphically on Plate 7. Full records of the progress in detail in sinking these foundations were kept and are given in Appendix C. The cost of sinking is given in Appendix D.

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The cost of the four pneumatic foundations is shown in detail in the following table:

	Cost, Excluding Freight Charges	Freight Charges	Cost, Including Freight Charges.			Cost, Excluding Freight Charges	Freight Charges	Cost, Including Freight Charges.	
FOUNDATION, PIER II.					Brought forward				
CAISSON—					FOUNDATION, PIER IV.				
Material	\$ 10 181.11	\$ 45.98	\$ 10 206.97		Material	\$ 14 881.44	\$ 10.00	\$ 14 876.44	
Labor	5 657.96		5 657.96	\$ 11 864.63	Labor	8 062.94		8 062.94	\$ 22 938.78
CONCRETE FILLING—					CONCRETE FILLING—				
Material	10 275.26	190.00	10 395.26		Material	11 804.12	3.60	11 807.72	
Labor	5 028.55		5 028.55	16 023.70	Labor	7 081.33		7 081.33	\$1 479.65
CUTTING EDGE, AIR LOCK, SHAFTS, ETC.	3 927.57		3 927.57	\$ 41 888.39	CUTTING EDGE, AIR LOCK, SHAFTS, ETC.	5 217.29	24.62	5 241.91	\$ 44 417.83
ERECTION AND REMOVAL OF MACHINERY	2 277.53		2 277.53	2 277.53	SINKING—				5 239.91
SINKING—					SINKING—				
Material	3 440.60	520.10	3 960.70		Material	3 259.06		3 259.06	
Labor	13 792.73		13 792.73	17 719.43	Labor	14 550.74		14 550.74	17 942.80
WORK TRAIN SERVICE	87.00		87.00			67 459.82	41.22		67 500.64
	55 207.96	691.09		\$ 55 899.95	FOUNDATION, PIER V.				
FOUNDATION, PIER III.					CAISSON—				
Material	13 540.55	16.83	13 557.38		Material	11 827.23	63.41	11 890.64	
Labor	7 377.23		7 377.23	20 934.66	Labor	6 379.20		6 379.20	18 269.83
CONCRETE FILLING—					CONCRETE FILLING—				
Material	10 926.53	5.98	10 932.51	16 808.68	Material	8 890.64	421.10	8 816.74	
Labor	5 870.17		5 870.17	87 743.34	Labor	6 943.86		6 943.86	15 760.87
CUTTING EDGE, AIR LOCK, SHAFTS, ETC.	4 899.26	10.81	4 910.07	4 910.07	CUTTING EDGE, AIR LOCK, SHAFTS, ETC.	3 355.10		3 355.10	\$ 555.10
ERECTION AND REMOVAL OF MACHINERY	1 995.50		1 995.50	1 995.50	SINKING—				
SINKING—					SINKING—				
Material	3 090.16	1.80	3 091.96	15 525.96	Material	2 424.59	383.55	2 808.14	
Labor	12 433.91		12 433.91		Labor	6 792.10		6 792.10	9 600.24
WORK TRAIN SERVICE	10.54		10.54		WORK TRAIN SERVICE	170.70		170.70	
	\$ 59 936.96	83.51		\$ 59 983.41		46 407.48	898.06		47 405.54
Carried forward				\$ 115 885.33	GRAND TOTAL COST OF FOUR FOUNDATIONS.....		\$229 114.86	\$ 1 656.73	\$230 781.61

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The cost and the quantities of masonry in the five piers are shown in detail in the following table :

	PIER I. ABUTMENT.		PIER II.		PIER III.		PIER IV.		PIER V.		
Masonry laid.	\$17.00	1 314.70 c. y.	\$22 350.92	3 787.71 c. y.	\$47 391.07	3 783.17 c. y.	\$47 433.89	3 784.55 c. y.	\$47 337.35	1 341.84 c. y.	\$33 811.39
Allowance for Granite hauled from St. Louis by barge, truck not being completed in time					434.91		834.59		402.73		
Drain Tile for Weepers			2.40								
Work Train Service			200.40		224.63		36.85		36.84		110.54
Portland Cement	@ \$3.02	5 bbls. \$ 15 10		130 bbls. \$392.40		253.5 bbls. \$755.07		273.5 bbls. \$820.97		73 bbls. \$220.46	
" "	@ 2.59	140 " 404.60		222 " 641.58		262 " 757.18		137 " 395.93		184 " 587.26	
Louisville Cement	@ 0.64	174 " 112.28		497 " 320.56							
" "	@ 0.63					275 " 170.50					
" "	@ 0.67	51 " 34.17					400 " 272.02		163 " 109.21		
Labor handling Cement		19.44		46.37		41.83		40.87		18.94	
			383.54		1 870.81		1 733.18		1 534.79		735.87
Total			\$28 139.26		\$49 421.62		\$50 110.51		\$49 311.73		\$33 637.69
Cost per Cubic Yard of Masonry.		17.60		17.73		17.94		17.71		17.63	
Average Cost per Cubic Yard of Masonry											17.75

The amount of masonry and concrete in the several piers and the amount of cement used is given in the following table :

				Cement, Bbls.				
	Masonry, Cu. Yds.	Concrete, Cu. Yds.	Total Cu. Yds.	In Masonry.		In Concrete.		Total.
				Portland.	Louisville.	Portland.	Louisville.	
Pier I.....	1 314.70	130.00	1 444.70	145.0	235	127	68	565
Pier II.....	2 787.71	2 333.00	5 121.71	343.0	467	1553	1638	4090
Pier III.....	2 763.17	3 510.90	6 304.07	515.5	275	887	4765	6482.5
Pier IV.....	2 784.55	4 351.30	7 035.85	410.5	400	1229	5055	7093.5
Pier V.....	1 341.84	3 198.00	4 539.84	297.0	163	1097	4057	5324
Total	11 022.03	13 415.20	24 437.23	1 690.0	1366	4866	16103	24175.0

THE BELLEFONTAINE BRIDGE.

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The cost of the five piers was as follows:

	Cost, EXCLUDING FREIGHT.	FREIGHT CHARGES	Cost, INCLUDING FREIGHT.	When Vertical Cost	Cost per Cubic Foot Concrete	Cable Fee, per Area, of base X feet x ft	Cost per Cubic Foot Concrete	Vertical Fee per Square Foot Low Water	Cost per Vertical Foot
FOUNDATION, PIER I (ABUTMENT)									
Excavation and Concrete	\$ 2 280.17	\$ 23.15	\$ 2 303.32						
	\$ 2 280.17	\$ 23.15	\$ 2 303.32						
FOUNDATION, PIER II									
Caisson and Filling, including Cutting Edge, etc.	85 030.10	105.86	85 135.96	81 840	42.22				
Sinking Caisson	17 108.38	520.10	17 719.43			143 700	12.33	69.43	\$ 298.94
Erection and Removal of Machinery	2 377.73		2 377.73						
Work Train Service	87.00		87.00						
	55 207.96	691.96	55 900.92						
FOUNDATION, PIER III									
Caisson and Filling, including Cutting Edge, etc.	42 419.70	33.63	42 453.33	127 903	33.17				
Sinking Caisson	15 324.07	1.89	15 325.96			186 322	8.32	88.82	174.50
Erection and Removal of Machinery	1 995.50		1 995.50						
Work Train Service	10.54		10.54						
	59 049.90	35.51	59 085.41						
FOUNDATION, PIER IV									
Caisson and Filling, including Cutting Edge, etc.	49 616.52	41.22	49 657.74	135 100	31.60				
Sinking Caisson	17 842.80		17 842.80			212 247	8.41	101.97	170.54
	67 459.32	41.22	67 500.54						
FOUNDATION, PIER V									
Caisson and Filling, including Cutting Edge, etc.	37 101.79	514.51	37 616.30	115 200	32.65				
Sinking Caisson	9 216.39	388.55	9 604.94			119 092	8.07	82.64	116.17
Work Train Service	179.70		179.70						
	46 497.88	898.06	47 395.94				Mean 9.17		Meta \$177.90
TOTAL COST OF FOUNDATIONS	\$ 231 408.83	\$ 1 088.00	\$ 232 496.83						
MASONRY, PIER I	23 120.69	9.57	23 130.26						
MASONRY, PIER II	40 304.19	97.38	40 401.57						
MASONRY, PIER III	50 110.51		50 110.51						
MASONRY, PIER IV	49 811.73		49 811.73						
MASONRY, PIER V	23 057.66		23 057.66						
TOTAL COST OF MASONRY	105 603.81	36.90	105 640.71						
GRAND TOTAL COST OF FIVE PIERS	\$ 487 007.94	\$ 1 726.50	\$ 488 734.44						

THE BELLEFONTAINE BRIDGE.

The total cost of each pier is given in the following table:

	Foundations.	Masonry.	Total.
Pier I.....	\$ 2 312.32	\$23 139.26	\$ 25 451.58
Pier II.....	51 890.92	49 421.52	105 321.44
Pier III.....	59 955.41	50 110.51	110 065.92
Pier IV.....	67 600.54	49 311.73	118 912.27
Pier V.....	47 395.54	23 637.09	71 032.63
TOTAL.....	\$203 095.73	\$195 640.71	\$428 736.44

IV.

SUPERSTRUCTURE.

The superstructure consists of four through spans. Each span is 440 feet long between centers of end pins and 55 feet deep, divided into eight panels of 55 feet each, which are subdivided into sixteen panels, each 27.5 feet long. The trusses are placed 30 feet between centers.

The double-track members of the superstructure are proportioned on a Class C basis, that is, on a basis of a moving load of 3 000 pounds per lineal foot of track, but the single-track members are proportioned on a Class A basis, that is, on a basis of 4 000 pounds per lineal foot. In proportioning the floor system these loads are doubled on a wheel base of 20 feet, and this double load is reduced at the rate of one per cent for each additional foot over 20 feet. The stringers, which are single-track members, are, therefore, proportioned for a moving load of 7 700 pounds per lineal foot, and the floor beams, which are double-track members, for a moving load of 5 775 pounds per lineal foot of track.

The entire superstructure is of steel.

The bridge is provided with a substantial steel fence on each side, this being for the protection of the watchmen and others who have to

cross the bridge and adding materially to the apparent strength of the structure.

Expansion is provided for on Piers II and IV. The details of the expansion bearings are of the form I have recently adopted for all bridges, using segmental rollers 12 inches in diameter, and distributing the weight over these rollers by a rocker plate with two cylindrical surfaces at right angles to each other, so that any possible irregularity is taken up.*

The trusses have single system webs and are made absolutely without adjustment; the top and bottom lateral systems are riveted. Full details of these trusses are given on Plates 9, 10, 11, 12 and 13. The strains and the basis under which they are computed are shown on Plate 14.

The full specifications for the superstructure are given in Appendix F. The record of the tests of full size bars is given in Appendix G.

The entire superstructure, except the eye bars, was manufactured by the New Jersey Steel & Iron Company who took the contract for the whole. The workmanship was unusually good.

The steel was rolled by the following parties:

Carbon Steel Company.
Carnegie Steel Company.
Midvale Steel Company.
Pencoyd Iron Works.
Pennsylvania Steel Company.

The steel castings were made by the Standard Steel Casting Company.

The eye bars, except the bottom chord bars for one span (which were made by the Union Bridge Company at Athens, Pa.), were manufactured at the Keystone Bridge Works, in Pittsburg.

The weights of the four spans were as follows:

I-II.....	2 795 906 lbs.
II III.....	2 807 928 "
III-IV.....	2 804 900 "
IV-V.....	2 819 007 "
	11 228 750 lbs.

As it is convenient for purposes of comparison to classify these weights, the average weight of the four spans may be distributed as follows:

* Patented October 23, 1892.

Classification.	Pounds.	Pounds per foot	Coefficients.
Trusses.....	1 890 292	4 316	0.81
Wind bracing.....	166 298	378	0.56
Floor.....	402 697	1 370	3.11
End Supports.....	87 004	198	0.45
Fence and Ladders.....	50 233	114	0.20
	2 805 554	6 376	14.49

The coefficients are the weights divided by the length of span.

The four spans were erected by Mr. William Baird whose experience in this class of work is greater than that of any other man living. The dates at which the several trusses were erected are shown in the following table:

	First Steel Placed	Span Swung.
Span I-II.....	December 10, 1893.	December 18, 1893.
Span II-III.....	September 4, 1893.	October 18, 1893.
Span III-IV.....	November 18, 1893.	November 27, 1893.
Span IV-V.....	November 3, 1893.	November 11, 1893.

The timber floor was laid by the company's men working under the direction of the Resident Engineer. The painting was done in the same manner.

The total cost of the superstructure is given in the following table:

STEEL WORK.			
Steel and Iron.....	\$429 359.50		
Freight Charges from Chicago.....	16 892.21		
		\$445 951.50	
Erection.....		79 526.16	
Cement, etc., for filling Castings.....		12 14	
Work Train Service.....		969.92	
			\$526 490.02
FLOOR.			
Material.....		9 904.74	
Freight.....		300.16	
Labor.....		2 508.63	
Work Train Service.....		67.28	
			12 780.84
PAINTING.			
Material.....		1 415.09	
Freight.....		32.95	
Labor.....		4 854.56	
Work Train Service.....		2.35	
			5 804.95
TOTAL SUPERSTRUCTURE.....			\$546 645.84

THE BELLEFONTAINE BRIDGE.

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V.

VIADUCT.

The viaduct at the north end of the bridge consists of 28 spans supported on 27 bents. The north bent is shorter than the others and is carried on a special masonry pier; the others are braced together into 13 towers. The spans are alternately 28' 6" and 32' 2" long, the shorter spans occurring over the towers. The viaduct is made throughout of the S steel of the specifications, the work being punched and riveted without reaming. It was manufactured and erected by A. & P. Roberts & Co. or the Pencoyd Iron Works.

The bracing of the towers is rigid without adjustment.

The girders over the towers are riveted rigidly to the tops of the towers, and the ends project slightly beyond the towers. The intermediate girders, which are of precisely the same length as those over the towers, are supported on these projecting ends. The actual bearing is taken on short pins which are split horizontally through the center, the whole being locked together by bronze keys in an arrangement which permits of a slight rocking of the bearing and of a slight longitudinal motion, the weight being transferred at the neutral axis, so that no sliding takes place under a moving load, the expansion occurring when the structure is light.

The bents and cross girders are proportioned on a Class C basis, the stringers on Class A basis.

The floor of the viaduct is identical with that of the main bridge.

The full details of this viaduct are shown on Plates 15 and 16.

The towers are supported on brick piers resting on piles. Piers 6, 7, 8 and 9 come between the restored shore line and the shore line as it existed when the work was begun; each of these piers has nine piles under it which were cut off at elevation 95 and support a timber grillage on which a block of concrete rests. Each of the other piers rests on seven piles which are buried in a block of concrete. All concrete blocks finish at elevation 101. Above the concrete the piers are built of Galesburg paving brick laid in Portland cement mortar and are finished with cast iron caps, the whole work being done by the company's men under the direction of the Resident Engineer.

The total amount of material in the viaduct piers is as follows:

	22 Small Piers.	Pier 22.	Total
Piles in work, 16 feet	12 705	1 431	15 196
Timber at work, feet R. M.	29 952		29 952
Concrete, cubic yards	851.57	151.85	1 003.42
Brick Masonry, cubic yards	440.94		440.94
Stone Masonry, cubic yards		162	162
Anchor Rods, pounds	17 775		17 775
Cast Iron Caps, pounds	72 215		72 215
Port and Cement, barrels	879	196	1 075
Louisville Cement, barrels	1 090	11	1 101

The total weight of the viaduct superstructure is as follows:

	Total Pounds.	Per Foot Pounds.
Towers	801 874	1 058
Girders	829 059	970
Piers	108 067	127
	1 738 999	2 156

As the average height of the viaduct from the cast iron caps to top of stringers is 47.66 feet the average weight per square foot of surface is 45.24 pounds equivalent to 22.62 pounds for a single track viaduct.

The cost of the piers is as follows:

	22 Small Piers.	Per 22	Total
Excavation and Refilling	\$2 010.63	\$ 119.37	\$2 121.00
Piles and Timber	5 462.12	479.15	5 941.27
Concrete	8 514.45	763.59	9 278.04
Brick Masonry	7 501.97		7 501.97
Stone Masonry		2 539.80	2 539.80
Anchor Rods	657.37		657.37
Cast Iron Caps	1 744.92		1 744.92
Regrasp	2 551.65		2 551.65
Total	\$28 838.01	\$3 502.94	\$32 425.85

The cost of the piers per lineal foot of viaduct is \$38.15.

The cost of the viaduct superstructure is as follows:

METAL WORK.			
Iron and Steel, erected	\$59 960.28		
Freight Charges from Chicago	2 864.82		
	\$62 825.14		
Work Train Service	190.53		\$63 015.67
FLOOR.			
Material	2 622.34		
Freight	63.59		
Labor	945.99		
Work Train Service	8.79		\$3 640.71
PAVING.			
Material	412.88		
Freight	13.56		
Labor	1 676.06		
Work Train Service	.79		\$2 103.29
TOTAL VIADUCT SUPERSTRUCTURE			\$69 739.87

The cost of superstructure per lineal foot of viaduct is \$80.88.

On the same basis used above for weights, the cost per square foot of surface of viaduct is \$1.697, or about 85 cents per square foot for a single track viaduct.

The total cost of the viaduct is \$101 156.82 and the total cost per lineal foot is \$119.03.

VI.

NORTH APPROACH.

The North Approach was built as a double-track trestle 2 960 feet long under the direction of the Resident Engineer. This trestle contains 1 437 763 feet board measure of timber and 35 220 lineal feet of piles. As it was intended to fill this trestle at once, perishable wood was used for piles, and no specification was made for sap in the timber.

North of this trestle is an earth embankment of ordinary description.

In June, 1894, a steam shovel was placed in the cut at the south end of the bridge and a regular force organized to take out this cut, working under the direction of the Resident Engineer. The plant in use consisted of a Barnhart Class "A. A." steam shovel, a special car fitted with a Lidgerwood Rapid Unloader, 60 flat cars fitted with aprons for the work, one Barnhart's standard center and one standard side ballast unloader, and a spreading plow made on the work. The material excavated from the cut was taken across the river and used to fill the trestle. About 325 000 cubic yards have been removed from the cut at the end of December, and it is expected that the whole work will be completed in the spring of 1895.

The cost of the earth work in the embankment of the North Approach and the filling of the trestle, is not included in the Table of Cost of the bridge, but forms part of the cost of grading the rail-road in the two counties of St. Charles and St. Louis.

VII.

PROTECTION WORK.

The only protection work on the south side of the river consists of a roughly pitched pavement upon the slope of the embankment which encloses the abutment.

On the north side of the river a considerable amount of protection was required. When the location of the bridge was first made the shore line was where Pier V now stands, but during the period which elapsed before actual construction began, about 150 feet of this shore was washed away, and it was thought best to restore the original shore line. The erosion at this point is of rather peculiar character; it does not occur at high water; one mile above the bridge Little's Island divides the river into two channels, the north channel being dry at low water; during high water, the water passing through the north channel throws the current against the south bluff at the bridge site, and no erosion takes place on the north shore; but at low water the entire current of the river passing south of Little's Island strikes the rocky bluff above the bridge and is deflected to the north shore. As this shore had to be protected only against the erosion of low or medium stage, the work was comparatively simple.

The work comprised two parts, the protection of the existing shore line and the restoration of the original shore line. The former was accomplished by a mat of the kind commonly used by the Missouri River Commission, and the latter by constructing a screen dike into the river. The location of this mat and dike is shown on Plate 18.

The mat is from 150 to 200 feet wide, formed of woven willows and covered with riprap. It was built in 1893. The shore was first trimmed to a slope of about three horizontal to one vertical, and on this the mat was woven extending out into the river; it was then loaded with rock and sunk; it was anchored to the shore by wire strands at intervals of 16 feet, every sixth strand being $\frac{1}{2}$ " diameter and the others $\frac{1}{4}$ ". The screen dike is a pile bridge, the piles being driven through a mat 100 feet wide which had previously been sunk on the bottom of the river, the mat not being woven like the shore mat, but built like those used by the Mississippi River Commission, a framework of poles being used above and below the brush and the whole wired together; a vertical mat similar to the shore mat, but of lighter character, was fastened to the outer side of the piles; this screen dike was built in 1892 and 1893. During the winter of 1893 this revetment was further strengthened by putting 853 cars of rock around the piles; it was originally intended to bring this filling rock to elevation 105 throughout, but it was not found expedient to do so, as the weight was evidently more than it was wise to put on the foundation mat.

The total amount of brush, rock and timber used in the protection work was as follows:

	Cords of Brush	Pounds of Riprap	Number of Piles	Feet B. M. Timber.
Protection Mat.....	3 535.54	23 686 948		
Screen Dike.....	1 767.73	41 224 199	206	208 020

In addition to the above there was used in temporary shore protection in 1892, 452 cords of brush and 1 451 358 pounds of stone.

The total cost of the protection work was \$67 691.02.

THE BELLEFONTAINE BRIDGE.

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VIII. COST.

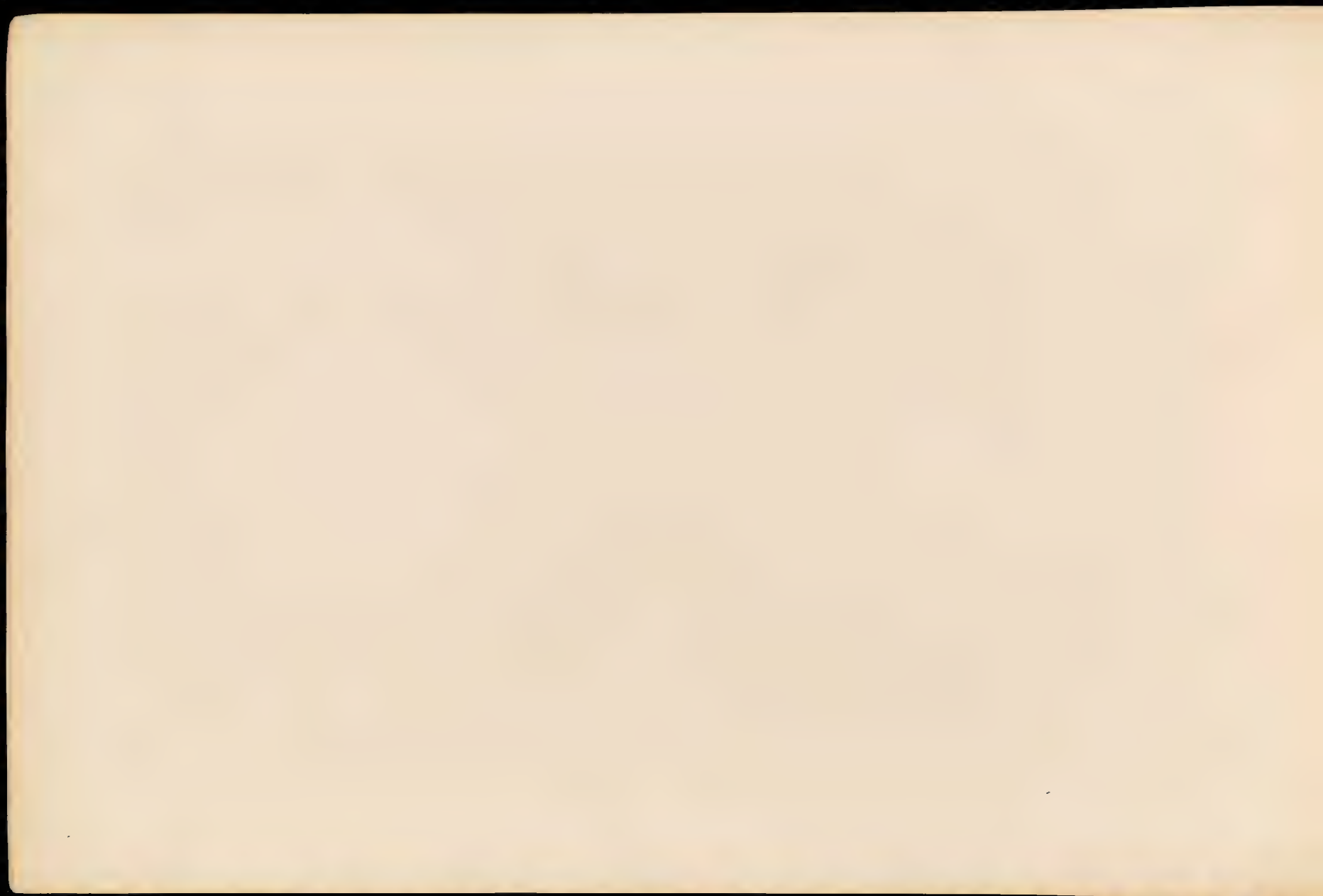
The cost of the bridge is shown in the following table:

	COST, EXCLUDING FREIGHT CHARGES.		FREIGHT CHARGES.	COST, INCLUDING FREIGHT CHARGES.	
Foundation, Pier I (Abutment).....	\$	2 280 17	\$	21.15	\$ 2 313 32
Foundation, Pier II.....		55 297.06		601.90	55 899.02
Foundation, Pier III.....		50 949.90		35.51	50 985.41
Foundation, Pier IV.....		67 459.32		11.22	67 500.54
Foundation, Pier V.....		48 497.48		898.06	47 399.54
Total Foundations.....	\$	231 493.83		\$ 1 069.90	\$ 233 069.73
Masonry, Pier I.....		25 129.01		9.57	25 138.58
Masonry, Pier II.....		49 384.19		27.83	49 412.02
Masonry, Pier III.....		36 110.51			36 110.51
Masonry, Pier IV.....		49 311.73			49 311.73
Masonry, Pier V.....		21 657.64			21 657.69
Total Masonry.....		195 603.14		38.90	195 640.71
Total Substructure.....	\$	427 097.04		\$ 1 730.80	\$ 428 734.44
Steel Work.....		510 067.81		16 592.21	526 660.02
Floor.....		13 450.68		300.16	13 750.84
Painting.....		3 772.00		32.98	3 804.98
Total Superstructure.....		528 330.49		16 925.35	545 045.84
Via-duct Foundations.....		30 533.05		1 892.90	32 425.95
Via-duct Superstructure.....		65 759.56		2 971.31	68 730.87
Total Via-duct.....		96 292.61		4 864.21	101 156.82
Timber Trestle.....		48 461.01		655.09	49 116.10
Total North Approach.....		141 753.62		5 518.39	150 273.92
Permanent Track.....		8 311.36		8.88	8 320.24
Shore Protection.....		84 075.16		1 613.86	85 689.02
Tools and Machinery.....		41 984.25		30.43	42 014.68
Service Tracks.....		13 993.47			13 993.47
Buildings.....		13 749.36		5.36	13 754.72
Real Estate.....		1 533.91			1 533.91
Watchdog.....		1 894.99			1 894.99
Total Sundry.....		73 085.98		35.69	73 121.67
Engineering Salaries.....		44 202.38			44 202.38
Engineering Expenses.....		5 090.80		30.02	5 120.88
Total Engineering.....		49 293.24		30.02	49 323.26
Total Cost.....		\$ 1 285 097.39		\$ 27 682.00	\$ 1 312 779.39

The item of freight includes freight on the C, B. & Q. system only. In comparing the cost of the bridge with that of other structures, the cost without freight forms the most correct basis for comparison.

This table may be condensed into the following:

	Cost, excluding Freight Charges.	Freight Charges.	Cost, including Freight Charges.
Substructure.....	\$427 097.04	\$ 1 730.80	\$428 734.44
Superstructure.....	528 330.49	16 715.35	545 045.84
Total Bridge Proper.....	955 427.53	18 446.15	973 789.28
North Approach.....	141 753.62	5 518.39	150 273.92
Permanent Track.....	8 311.36	8.88	8 320.24
Shore Protection.....	84 075.16	1 613.86	85 689.02
Tools, Service Tracks, et.....	73 085.98	35.69	73 121.67
Engineering.....	49 293.24	30.02	49 323.26
Total Cost.....	\$1 285 097.39	\$27 682.00	\$1 312 779.39







APPENDIX A.

LIST OF ENGINEERS, EMPLOYEES AND CONTRACTORS.

ENGINEERS AND COMPANY'S EMPLOYEES.

NAME AND OCCUPATION.	TIME OF SERVICE.
GEORGE S. MORRISON, Chief Engineer.	
ALFRED NOBLE, Assistant Chief Engineer.	
BEN. L. CROSBY, Resident Engineer	Feb. 20, 1892, to date.
ERNEST G. FREEMAN, Assistant Engineer	July 1, 1892, to Dec. 31, 1893
HOMER REED STANFORD, " "	April 1, 1892, to Aug. 18, 1892
WM. G. BRENNERKE, " "	June 23, 1892, to June 30, 1894
WM. L. SMITH, " "	Aug. 20, 1892, to Jan. 31, 1894
JAMES W. G. WALKER, " "	Aug. 25, 1892, to July 31, 1893
WM. R. JOHNSON, Inspector	July 1, 1892, to July 15, 1893
AUGUST T. HOLMGREN, Rodman and Inspector	Mar. 22, 1893, to June 30, 1894
JOHN F. LINDORSEN, Cement Tester	July 26, 1892, to Dec. 31, 1893
JAMES M. RICHARDSON, Clerk	July 8, 1892, to date.
ROBERT F. TRAYER, Timekeeper	June 4, 1892, to Feb. 16, 1894
DAVID NOWLIN, M. D., Resident Physician	Sept. 26, 1892, to July 31, 1893
H. H. BORN, M. D., " "	Aug. 1, 1893, to Dec. 31, 1893
E. GERBER, Office Engineer.	
O. E. HOVEY, Chief Superstructure Draughtsman.	
I. DICKINSON, Record Draughtsman.	
HOMER REED STANFORD, Insp'r of Superstructure	Aug. 19, 1892, to Oct. 31, 1893
CHARLES STEARS, Inspector at Quarries	May 13, 1892, to Sept. 17, 1892
O. W. DAVIS, " " "	Mar. 1, 1893, to May 31, 1893
L. S. STEWART, General Foreman	May 1, 1892, to May 15, 1893
DENNIS LEONARD, Foreman of Pressure Work	June 15, 1892, to May 3, 1893
M. F. CONER, Foreman of Carpenters	June 27, 1892, to June 30, 1894
GEORGE CAPEL, Master Mechanic	July 27, 1892, to June 3, 1893
JOHN M. GILHAM, Master of Steamers	
PAULINE and JOHN BERTRAM	Aug. 25, 1892, to date.

CONTRACTORS.

CHRISTIE & LOWE	Masonry.
GEO. A. LEDERLE	Resident Partner.
CHARLES STEARS	Foreman of Masons.
NEW JERSEY STEEL & IRON COMPANY	Superstructure.
WILLIAM BAIRD	Erection.
A. & P. ROBERTS & COMPANY	Viaduct.
JOHN EAGLER	Foreman of Erection.
JOSEPH K. GOLIKE	Mattress Brush and Riprap.
MOORESVILLE STONE COMPANY	Riprap.

APPENDIX B.

CHARTER AND CONTRACT WITH WAR DEPARTMENT.

CHARTER.

AN ACT AUTHORIZING THE CONSTRUCTION OF A BRIDGE ACROSS THE MISSOURI RIVER AT SOME ACCESSIBLE POINT IN THE COUNTY OF SAINT CHARLES, IN THE STATE OF MISSOURI, BELOW THE CITY OF SAINT CHARLES.

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That the Saint Louis, Keokuk & Northwestern Railroad Company, an incorporation organized under the laws of the State of Iowa, and owning and operating a railroad in the State of Missouri, its assigns or successors, is hereby authorized to construct and maintain a bridge across the Missouri River at such point as may be hereafter selected by said corporation between the City of Saint Charles and the mouth of the Missouri River, in the County of Saint Charles, in the State of Missouri, as shall best promote the public convenience and welfare and the necessities of business and commerce; and also to construct accessory works to secure the best practicable channel way for navigation, and confine the flow of the water to a permanent channel at such point, and to lay on and over said bridge one or more railroad tracks for the more perfect connection of any railroads that are or shall be constructed to said river at or opposite said point.

SEC. 2. That said bridge shall be constructed and built without interference with the security and convenience of navigation of said river beyond what is necessary to carry into effect the rights and privileges hereby granted; and in order to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines to high and low water, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War, the

bridge shall not be built: PROVIDED, that if the said bridge shall be made with unbroken and continuous spans, it shall have three or more channel spans, and shall not be of less elevation in any case than fifty feet above high-water mark, as understood at the point of location, to the lowest part of the superstructure, nor shall the spans of said bridge be less than three hundred feet in length, and the piers of said bridge shall be parallel with the current of said river, and the main span shall be over the main channel of the river, and not less than three hundred feet in length: AND PROVIDED ALSO, that if any bridge built under this act shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river at an accessible and navigable point, and with spans of not less than one hundred and sixty feet in length in the clear on each side of the central or pivot pier of the draw, and the next adjoining span or spans to the draw shall not be less than three hundred feet, and the head room under such span shall not be less than ten feet above high-water mark: PROVIDED ALSO, that said draw shall be opened promptly upon reasonable signal for the passing of boats; and said company or corporation shall maintain, at its own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe: PROVIDED ALSO, that all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them desiring such use, shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proofs of the parties.

SEC. 3. That the Secretary of War is hereby authorized and directed, upon receiving such plan and map and other information, and upon being satisfied that a bridge built on such plan, and with such accessory works and at such locality, will

conform to the prescribed conditions of this act, to notify the company that he approves the same; and upon receiving such notification the said company may proceed to an erection of said bridge, conforming strictly to the approved plan and location; and should any change be made in the plan of the bridge or said accessory works, during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the Circuit Court of the United States of the Eastern District of the State of Missouri, in whose jurisdiction any portion of said obstruction or bridge may be located.

SEC. 4. That the said bridge and accessory works, when built and constructed under this act and according to the terms and limitations thereof, shall be lawful structures; and said bridge shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and said bridge shall enjoy the rights and privileges of other post-routes in the United States.

SEC. 5. That the United States shall have the right of way for such postal and telegraph lines across said bridge as the government may construct or control.

SEC. 6. That Congress shall have power at any time to alter, amend or repeal this act, so as to prevent or remove all material and substantial obstructions to the navigation of said river by the construction of said bridge and its accessory works; and all alterations of said bridge shall be made, and all such obstructions shall be removed at the expense of the owners of or persons controlling such bridge. PROVIDED FURTHER, that nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

Approved, February 17, 1888.

APPENDIX B.—CONTINUED

CONTRACT WITH WAR DEPARTMENT.

WHEREAS, By an act of Congress, approved February 17th, 1888, entitled "An act authorizing the construction of a bridge across the Missouri River at some accessible point in the County of St. Charles, in the State of Missouri, below the City of St. Charles," the St. Louis, Keokuk & Northwestern Railroad Company, a corporation existing under the laws of the State of Iowa, and owning and operating a railroad in the State of Missouri, its successors and assigns, was authorized to construct and maintain a railroad bridge across the Missouri River at such point as might be selected by said corporation, between the City of St. Charles and the mouth of the Missouri River, in the County of St. Charles, in the State of Missouri, and as would best promote the public convenience and welfare and the necessities of business and commerce; and, also, to construct accessory works to secure the best practicable channel-way for navigation, and confine the flow of the water to a permanent channel at such point; and,

WHEREAS, It is provided by section two of the said Act, "That said bridge shall be constructed and built without interference with the security and convenience of navigation of said river, beyond what is necessary to carry into effect the rights and privileges hereby granted; and in order to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge, and a map of the location, giving for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines to high and low water, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and

location of the bridge are approved by the Secretary of War, the bridge shall not be built;" and by section three of the said act, "That the Secretary of War is hereby authorized and directed, upon receiving such plan and map and other information, and upon being satisfied that a bridge built on such plan and with such accessory works and at such locality will conform to the prescribed conditions of this act, to notify the company that he approves the same; and upon receiving such notification the said company may proceed to an erection of said bridge, conforming strictly to the approved plan and location; and should any change be made in the plan of the bridge or said accessory works, during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War;" and.

WHEREAS, The St. Louis, Keokuk & Northwestern Railroad Company aforesaid has accepted the provisions of the Act of Congress aforesaid, and, in compliance therewith, has submitted to the Secretary of War, for his examination and approval, a design and drawing and a map of location of a proposed bridge across the Missouri River at a point between the City of St. Charles and the mouth of the Missouri River, in the County of St. Charles, State of Missouri; and, Lieutenant-Colonel Charles R. Suter, corps of engineers, reports that the plans submitted conform to the requirements of the said act, and also to the requirements which had been deemed necessary by the Missouri River Commission, and recommends that they be approved, and the Chief of Engineers, United States Army, concurs in said recommendation.

Now, therefore, I, Redfield Proctor, Secretary of War, having examined and considered the design and drawing and the map of location aforesaid, submitted by the St. Louis, Keokuk & Northwestern Railroad Company as aforesaid, and which

are hereto attached, do hereby approve the same, subject, however, to the following express condition:

1. That the Engineer Officer of the United States Army, in charge of the district within which the bridge is to be built, may supervise its construction so far as may be necessary in order that the plans herein approved shall be complied with and the bridge built accordingly.

Witness my hand this 21st day of December, 1889.

(Signed) REDFIELD PROCTOR,
Secretary of War.

This instrument is also executed by the St. Louis, Keokuk & Northwestern Railroad Company by W. W. Baldwin, its President, thereto lawfully authorized, this 14th day of December, 1889, in testimony of the acceptance by said company of the provisions of the Act of Congress aforesaid, and of the condition herein imposed.

(Signed) THE ST. LOUIS, KEOKUK & NORTHWESTERN RAILROAD COMPANY,
By W. W. BALDWIN,

President.

In presence of
(Sgd.) H. E. JARVIS.

Attest: (Sgd.) J. H. STEEDS,
Secretary.

[Seal of R. R. Co.]

[Seal United States of America—War Office.]

APPENDIX C.-CONTINUED.
 RECORD OF SINKING CAISSONS.
 PIER III.

Observations taken at 8 o'clock.

Date	ELEVATIONS OF CUTTING EDGE					SINKAGE		ELEVATIONS OF GROUND					Average Per cent of Caisson.	Water Level		Weights							Air Pressure		Reaction Pressure	Net Weight	Surface Contact	Average Volume per Foot surface exposed to friction	Material	Remarks	
	N. E.	N. W.	S. E.	S. W.	Average	In Inch	Feet	N. E.	N. W.	S. E.	S. W.	Average		Feet	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.							Lbs.
1899.																															
Aug 20																														Cutting edge set up July 20.
21	86 11	86 78	83 28	85 18	86 07			86 70	86 70	85 70	87 70	86 70	0 63	96 23	9 13	362	35	5					392			322	123	4282	...		Caisson launched
22	85 06	86 07	84 85	85 11	85 27	0 60	0 70	85 58	86 51	85 08	87 18	86 32	0 55	96 08	8 91	369	36					431			374	116	6436	...		Caisson placed in position at 13:50 o'clock.	
23	85 51	86 11	84 27	85 21	85 26	0 48	0 78	85 91	86 51	85 29	87 03	86 18	0 67	94 70	9 41	355	36	276	9			619			613	171	7115	...		Concreting commenced.	
24	85 36	85 60	83 91	84 14	84 56	0 43	1 21	86 13	86 57	85 85	86 65	86 25	1 30	94 67	9 79	371	40	486	9			906			906	278	6518	...			
25	85 78	85 59	83 80	84 38	84 76	0 10	1 31	86 02	86 43	85 56	86 69	86 15	1 30	94 60	9 84	371	43	486	10			910			910	279	6423	...			
Sept 1	85 09	85 10	83 69	84 05	84 50	0 36	1 37	86 10	86 44	86 43	86 27	86 31	1 31	94 60	10 10	388	43	789	10			1250			1228	360	6841	Medium Sand.		Air pumps started at 9:23 o'clock, sand pumps at 11:10.	
2	82 08	82 81	83 23	83 41	83 08	1 42	2 30	86 16	86 44	86 45	85 11	86 12	3 04	94 78	11 20	402	44	1071	10			1327	5 4	4 90	734	753	607	2547	...		
3	81 03	79 71	80 64	79 53	80 33	2 35	5 84	85 60	85 30	90 85	91 80	88 29	8 16	94 59	11 27	426	44	1292	10			1382	7 0	6 16	937	847	1020	1020	...		
4	77 83	78 78	78 01	79 08	78 44	1 79	7 63	81 00	85 40	98 10	94 05	89 64	11 20	94 47	15 03	188	45	1594	11			2158	5 25	6 91	1044	1064	2238	951	...		
5	75 19	75 39	75 47	75 92	75 49	3 95	10 58	86 01	86 16	95 89	94 12	90 76	11 27	94 41	18 02	400	51	1564	11			2158	9 08	8 21	1249	885	2443	580	...		
6	72 10	72 12	72 13	72 69	72 38	3 16	13 74	85 15	84 15	91 97	91 10	89 84	17 51	94 36	22 04	526	51	1837	12			2420	10 50	9 56	1444	982	3208	561	Fine Sand		
7	70 15	69 94	70 12	70 18	70 09	2 24	13 98	85 07	84 65	95 28	94 85	90 06	19 97	94 30	24 11	516	52	2181	13			2792	11 70	10 16	1580	1212	3965	617	Course		
8	67 95	68 92	67 48	68 17	68 32	1 87	17 85	85 34	84 97	95 50	96 00	90 29	21 98	94 25	26 08	580	53	2415	13			3061	12 25	11 39	1705	1346	4898	617	...		
9	66 32	65 95	66 43	66 31	66 25	1 97	19 32	85 18	84 80	95 78	95 33	90 26	24 11	94 23	27 97	591	56	2766	15			3128	13 00	12 11	1892	1595	4822	692	...		
10	64 08	64 93	61 88	65 38	64 97	1 28	21 10	85 10	85 29	95 80	95 40	91 38	25 41	94 15	29 18	622	56	3217	16			3611	13 50	12 66	1912	1999	5682	772	...		
11	62 58	62 33	62 82	63 02	62 74	2 23	23 38	85 11	85 53	95 47	95 63	90 44	27 70	94 10	31 86	632	58	3439	16			4163	14 50	13 61	2055	2 10	5540	762	...		
12	60 18	60 94	60 55	61 76	60 81	1 68	25 36	84 81	85 35	95 30	95 83	90 32	29 51	94 19	34 38	672	59	3439	16			4168	15 00	14 40	2180	1977	5903	670	...		
13	58 04	58 33	58 41	58 95	58 43	2 38	27 04	84 82	85 29	95 28	95 80	90 28	31 85	94 76	36 33	699	61	3750	17			4720	17 00	15 77	2382	1988	6370	690	Fine Sand		
14	56 27	56 66	56 79	57 42	56 79	1 64	29 28	84 02	85 02	95 90	96 14	90 49	33 70	94 27	37 48	742	66	3498	19			4655	17 73	16 37	2458	2197	6741	632	Medium Sand with clay lumps.		
15	55 61	54 91	55 80	55 33	55 42	1 37	30 65	85 60	85 70	95 47	96 24	90 75	35 43	94 07	38 65	773	71	4101	19			4908	18 50	16 77	2343	2435	7073	689	...		
16	53 85	54 51	53 90	52 81	53 87	3 15	33 60	85 36	86 36	95 71	96 36	90 90	39 69	93 86	41 20	783	71	4439	20			5013	19 00	18 05	2727	2586	7725	670	...		
17	51 20	50 97	51 07	51 70	51 43	0 79	34 50	85 26	86 48	96 43	96 58	90 94	39 49	94 08	42 30	822	72	4682	20			5576	20 00	18 81	2766	2810	7898	712	...		
18	50 14	49 53	50 68	50 42	50 17	1 31	35 90	85 18	86 22	95 10	96 48	90 75	40 68	93 49	43 29	832	73	4940	20			5663	19 25	18 70	2868	3027	8014	746	...		
19	48 41	47 90	48 82	48 46	48 37	1 30	37 70	85 00	86 78	94 61	96 00	90 92	42 55	95 33	44 98	932	73	4940	20			5965	20 50	19 34	2947	2918	8510	688	...		
20	46 40	46 04	46 90	46 73	46 53	1 84	39 51	85 50	86 12	94 80	96 57	90 75	44 22	93 35	46 70	842	73	5217	22			6149	21 00	20 28	3093	3090	8843	698	...		
21	44 11	43 73	44 33	44 40	44 19	3 24	41 88	85 48	86 50	92 94	92 40	89 31	45 12	93 19	49 00	842	73	5440	23			6578	22 50	21 37	3212	3165	9922	702	...	Truster work on caisson finished, air taken off at 11:45 o'clock, and Bertram moved to shore	
22	44 07	43 72	44 47	44 37	44 16	0 03	41 91	85 12	86 17	93 10	93 10	89 37	45 31	93 10	49 94	842	74	5824	23			6763	...	...	6764	9043	1498	...		
23	44 07	43 72	44 46	44 38	44 15	0 01	41 92	85 20	86 32	93 04	93 21	89 44	45 29	93 04	48 98	842	74	5992	24	.....		6992	...	...	6992	9059	1530	...	Concreting finished.	

APPENDIX C.—CONTINUED.
 RECORD OF SINKING CAISSONS.
 PIER III.—CONTINUED.

Observations taken at 8 o'clock

Date	ELEVATION OF CUTTING EDGE					SINKING		ELEVATION OF GROUND					Average 1 ft. to 10 ft.	Water Gauge	Depth in fms.	WINDS										AIR PRESSURE		Barometer at Station	Net Weight	Surface in Contact	ATmospheric Pressure		MATERIAL	REMARKS
	N	NW	W	SW	Average	In Hours	Feet	N	NE	E	SE	S				Caiss.	Timber	Iron	Steel	Water	Total	1 ft.	10 ft.	Lbs.	Lbs.	1 ft.	10 ft.							
1892																																		
Dec 4	44.06	43.71	44.44	44.34	44.14	0 01	41.03	91.50	81.40	95.50	88.90	89.10	44.90	92.30	48.16	8.2	71	692	21	895	7760	20.50	50.00	3157	4603	8092	1624							Laying masonry commenced Nov. 9th. { Air pump (stationary plant) started at 15.00 o'clock and sand pump at 16.00 o'clock Dec. 3
5	44.02	43.61	44.10	44.21	44.07	0 07	42.20	91.60	81.60	95.60	89.00	89.20	44.13	92.40	48.16	8.2	71	692	21	895	7760	20.50	50.00	3157	4603	8092	1624							
6	43.18	43.00	44.00	43.72	43.43	2 08	44.78	91.80	81.80	95.80	89.20	89.40	43.56	92.60	48.16	8.2	71	692	21	895	7760	20.50	50.00	3157	4603	8092	1624							
7	42.44	42.28	43.28	43.00	42.74	1 27	46.11	92.00	82.00	96.00	89.40	89.60	42.92	92.80	48.16	8.2	71	692	21	895	7760	20.50	50.00	3157	4603	8092	1624							
8	39.61	41.90	39.20	39.34	39.11	3 57	44.96	91.00	81.20	95.80	88.30	88.50	42.47	92.30	48.16	8.2	71	692	21	895	7760	20.50	50.00	3157	4603	8092	1624							
9	42.07	41.18	42.00	42.50	42.23	1 51	42.82	91.10	81.00	95.80	88.80	89.00	42.67	92.30	48.16	8.2	71	692	21	895	7760	20.50	50.00	3157	4603	8092	1624							
10	40.77	40.60	40.81	40.94	40.79	1 40	42.88	91.80	81.80	95.80	88.92	89.12	42.13	92.40	48.16	8.2	71	692	21	895	7760	20.50	50.00	3157	4603	8092	1624							
11	42.47	42.94	42.77	42.18	42.56	3 53	48.81	90.20	80.20	95.00	87.00	87.10	40.84	91.20	48.16	8.2	71	692	21	895	129	8128	28.00	38.02	4323	3845	11474	646						
12	42.46	42.32	42.46	42.17	42.35	0 01	48.82	86.00	76.00	92.00	88.00	88.10	39.88	90.20	48.16	8.2	71	692	21	895	129	8128	28.00	38.02	4323	3845	11474	646						
13	42.42	42.30	42.41	42.18	42.33	0 02	48.84	86.80	76.80	92.00	88.00	88.10	39.88	90.20	48.16	8.2	71	692	21	895	127	8317	28.00	38.02	4315	3838	11466	638						
14	42.04	42.78	42.63	42.00	42.59	1 27	49.11	86.40	76.40	92.00	87.27	87.31	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
15	42.11	42.94	42.50	42.17	42.68	2 35	49.60	86.30	76.30	92.00	87.63	87.67	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
16	42.10	42.84	42.76	42.86	42.76	1 32	49.31	85.70	75.70	92.00	87.63	87.67	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
17	42.07	42.82	42.80	42.80	42.82	2 54	47.15	84.70	74.70	92.00	87.63	87.67	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
18	41.03	41.88	41.84	41.04	41.02	4 00	41.15	84.70	74.70	92.00	87.63	87.67	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
19	41.70	41.90	41.69	42.05	41.86	3 06	42.91	85.50	75.50	92.40	87.40	87.49	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
20	40.60	40.67	40.48	40.77	40.61	2 53	46.46	82.30	72.30	93.00	87.50	87.58	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
21	42.11	42.11	42.10	42.31	42.23	1 41	47.87	82.10	72.10	92.80	88.00	88.09	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
22	41.60	41.61	41.61	41.07	41.61	1 26	47.13	81.60	71.60	92.00	88.00	88.03	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
23	41.78	41.82	41.83	41.60	41.82	2 12	41.25	80.20	70.20	91.20	87.40	87.43	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
24	41.59	41.61	41.61	41.11	41.70	1 03	42.28	80.60	70.60	90.80	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
25	41.57	41.70	41.62	41.09	41.77	0 02	42.30	81.00	71.00	91.20	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
26	41.57	41.70	41.62	41.09	41.77	0 01	42.30	80.90	70.90	91.10	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
27	41.57	41.70	41.62	41.09	41.77	0 02	42.32	79.40	69.40	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
28	41.57	41.70	41.62	41.09	41.77	0 03	42.32	79.40	69.40	91.20	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
29	41.57	41.70	41.62	41.09	41.77	0 01	42.33	79.40	69.40	91.20	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
30	41.57	41.70	41.62	41.09	41.77	0 01	42.33	79.40	69.40	91.20	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
31	41.57	41.70	41.62	41.09	41.77	0 04	42.38	78.60	68.60	91.20	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
1893																																		
Jan. 1	42.83	42.80	42.80	42.77	42.80	0 10	42.87	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
2	42.80	42.80	42.80	42.80	42.80	0 31	42.88	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
3	42.80	42.80	42.80	42.80	42.80	0 11	42.88	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
4	42.80	42.80	42.80	42.80	42.80	0 11	42.88	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
5	42.80	42.80	42.80	42.80	42.80	0 11	42.88	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
6	42.80	42.80	42.80	42.80	42.80	0 11	42.88	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
7	42.80	42.80	42.80	42.80	42.80	0 11	42.88	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						
8	42.80	42.80	42.80	42.80	42.80	0 11	42.88	80.90	70.90	91.00	87.60	87.61	31.30	86.04	843	74	502	30	1519	14	149	8019	28.50	39.05	4268	425	12249	561						

Pumping finished at 10.35 o'clock. Sealing commenced
 { Sealing finished at 17.20 o'clock Jan. 11, air taken off 7.30
 o'clock Jan. 12.

APPENDIX C.—CONTINUED. RECORD OF SINKING CAISSONS.

PIER IV.

Observations taken at 8 o'clock.

DATE	ELEVATIONS OF CUTTING EDGE					ELEVATIONS OF GROUND					Average Per cent No. of Caisson	Water stage	Depth measured	WEIGHTS					AIR PRESSURE		Reaction at Air Pressure	Net Weight	Surface Contact	Average Weight per sq. ft. surface exposed to friction	MATERIAL	REMARKS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	N	E	S	W	Average	In Feet	Tot.	N	E	S				W	Average	Calano.		WELTHS		Indi- cated							Comp- ared																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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Framing of caisson timber commenced Aug. 18th. Cut-
ting edge set up Aug. 20th. Caisson launched Sept. 20th.
Caisson located at site of pier.

Water pumped out of caisson.
Concreting commenced at 8.50 o'clock.

Air pumps started at 7.45, sand pumps at 10.05 o'clock

Sand pumps stopped at 2.50 o'clock. Caisson straightened
by repairing working chamber. Sand pumps resumed work
at 10.28 o'clock

Method used in
Heavy sand

Fine blue sand

Fine sand
with clay balls

Timber work of caisson finished.

Concreting of caisson finished.

Laying of masonry commenced

APPENDIX C.—CONTINUED.
 RECORD OF SINKING CAISSONS.
 PIER IV.—CONTINUED.

Observations taken at 8 o'clock.

Date	ELEVATIONS OF CUTTING EDGE					SINKAGE		ELEVATIONS OF GROUND					Average Penetration Per Foot of Caisson	Water Gauge	Depth Increased	Weights										Air Pressure		Reaction Due to Air Pressure	Net Weight	Surface Contact	Average Weight Per Sq. Ft. of surface in contact		Material	REMARKS	
	N E	N W	S E	S W	Average	In 24 Hours	Total	N. E.	N. W.	S. E.	S. W.	Average				Caisson	Timber	Iron	C. & S.	A.P. Lbs. per Sq. Ft.	M. & S. & P.	Soil	Water	Total	Lbs. per Sq. Ft.	Lbs.	Tons				Tons	Sq. ft.			Lbs.
1862.						Fl.	Fl.						Fl.			Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Lbs.	Lbs.	Tons	Tons	Sq. ft.	Lbs.					
Oct. 26	21 21	20 25	21 26	20 40	20 81	0 00	62 10	75.00	66.20	73.00	74.00	72.70	31 89	92 46	71.55	1031	86	7290	38	311				8600	32 00	31 03	4890	2676	10370	766			Coarse sand.		
27	19 24	18 54	20 03	19 18	19 19	1 32	63 51	76.30	71.70	75.00	73.90	71.40	34 91	92 85	72 86	1031	86	7290	38	446				8843	32 75	31 05	4776	2667	10373	741					
28	17 36	16 50	17 44	16 08	17 17	2 82	65 83	80 10	72 50	77.30	75.30	76 40	33 23	92 65	75 43	1031	86	7248	30	796			9138	33 00	32 78	4940	3189	118 86	708					
29	14 02	14 03	14 08	14 59	14 75	2 12	68 23	81 30	74 70	76 90	73 00	75 52	31 77	93 57	78 82	1031	86	7269	30	919			129	34 50	34 21	5103	3275	123 54	692					
30	13 21	12 55	12 28	12 02	12 06	1 40	69 04	76 70	73 20	79 90	74 00	76 70	33 84	93 78	80 73	1031	86	7298	33	1149			190	37 34	35 04	5293	4441	127 28	698					
31	10 51	10 50	10 53	10 32	10 42	2 44	72 58	79 40	73 90	82 00	77 00	78 07	37 65	93 70	83 28	1031	86	7280	38	1172			278	38 12	36 00	5470	5883	135 32	648					
Nov. 1	8 68	8 52	8 72	8 56	8 63	1 80	74 38	79 70	80 70	83 50	78 50	80 60	71 88	96 70	84 88	1031	86	7290	39	1317			329	100 11	100 20	5663	4476	148 66	622					
2	7 07	6 27	7 06	6 26	6 27	1 83	76 03	81 80	81 80	84 10	76 10	80 33	73 08	98 30	89 33	1031	86	7290	40	1512			377	102 85	87 25	5747	4625	147 97	625					
3	3 03	3 34	3 09	3 30	3 34	3 81	79 30	79 40	79 40	83 00	75 00	79 50	73 80	93 10	89 49	1031	86	7290	40	1761	74	442	10678	38 46	38 84	5867	4806	150 88	687						
4	1 12	1 75	1 32	1 75	1 84	1 77	81 16	83 00	83 00	88 00	80 00	82 25	80 41	93 00	91 16	1031	86	7290	41	1966	275	365	11 01	38 50	39 56	5870	5625	150 01	644						
5	0 30	0 32	0 56	0 49	0 54	1 20	82 46	83 50	80 00	86 00	81 00	88 00	85 46	92 90	92 36	1031	86	7290	43	2168	342	342	11 30	40 50	40 08	6034	5547	160 10	657						
6	-0 50	-1 33	-0 89	-1 06	-0 91	1 45	84 91	83 30	80 30	89 10	81 10	83 43	84 28	92 80	93 71	1031	86	7290	43	2286	490	316	11 50	42 06	40 67	6143	5337	163 38	678						
7	-2 75	-2 82	-1 82	-2 83	-2 82	1 91	84 82	85 55	77 70	88 50	81 00	83 30	86 02	92 70	93 32	1031	86	7293	44	2385	580	322	11 56	41 50	41 46	6263	5634	164 64	646						
8	-4 11	-4 12	-4 18	-4 13	-4 10	1 33	87 18	88 00	79 00	82 00	83 43	87 58	92 70	98 88	98 70	1031	86	7289	44	2437	673	315	11 55	42 50	43 03	6340	5478	167 04	634						
9	-5 6	-5 6	-5 78	-5 78	-5 71	1 56	88 71	89 00	82 40	88 40	85 40	84 90	90 81	96 60	98 51	1031	86	7290	44	2518	809	262	11 98	43 00	43 07	6448	5548	171 47	646						
10	-6 01	-6 03	-6 07	-7 01	-6 06	1 25	89 90	84 40	84 40	87 90	87 00	85 92	92 88	92 70	100 66	1031	86	7293	44	2618	963	291	12 12	43 00	43 20	6533	5579	174 03	636						
11	-7 52	-7 50	-8 02	-7 09	-7 05	0 39	90 95	86 81	90 80	81 20	87 20	89 77	97 70	92 60	100 55	1031	86	7290	44	2618	1280	97	12 23	43 75	41 01	6592	5614	181 03	625	Gravel and boulders.					
12	-7 41	-7 41	-8 05	-8 02	-7 98	0 03	91 18	89 10	89 30	80 00	86 00	88 60	96 38	92 60	100 08	1031	86	7290	44	2618	1198	135	12 23	44 50	43 65	6291	5619	179 07	627						
13	-8 55	-8 38	-8 18	-8 14	-8 08	0 11	91 08	88 70	78 80	88 90	78 00	83 80	91 89	92 00	100 09	1031	86	7290	44	2618	960	300	12 07	44 00	43 70	6601	5520	178 05	628						
14	-8 40	-8 36	-8 52	-8 48	-8 44	0 35	91 44	86 00	78 60	88 80	79 80	83 45	91 89	12 06	101 04	1031	86	7290	44	2618	960	314	12 10	44 50	43 85	6624	5516	178 05	637						
15	-8 53	-8 50	-9 02	-8 05	-8 50	0 45	91 80	85 00	77 80	88 30	76 30	82 75	91 64	12 06	101 30	1031	86	7293	44	2618	885	327	12 10	45 50	44 08	6654	5496	172 19	636						
16	-8 53	-8 50	-9 02	-8 53	-8 50	0 40	91 80	84 50	76 50	84 70	80 70	81 85	90 74	12 30	101 39	1031	86	7269	44	2618	897	304	12 10	44 25	44 00	6646	5473	171 00	638						
17	-8 53	-8 50	-9 02	-8 53	-8 50	0 40	91 80	85 30	75 80	84 10	80 10	81 32	90 21	12 30	101 40	1031	86	7290	44	2618	917	306	12 12	44 00	44 00	6654	5467	170 32	640						
18	-8 53	-8 50	-9 02	-8 53	-8 50	0 40	91 80	86 30	76 60	84 50	78 10	82 02	91 51	12 30	101 39	1031	86	7290	44	2618	888	309	12 14	44 75	44 00	6648	5488	172 66	637			Final settlement made at 15.00 o'clock.			
19	-9 17	-9 03	-9 12	-9 18	-9 17	0 28	92 17	85 96	77 40	86 20	77 00	83 02	91 79	12 30	101 37	1031	86	7269	44	2618	906	314	12 15	45 01	44 08	6649	5496	173 05	635			Pumping finished at 19.00 o'clock.			
20	-9 17	-9 03	-9 32	-9 18	-9 17	0 00	92 17	86 10	77 10	90 30	77 80	82 80	91 97	12 30	101 77	1031	86	7290	44	2618	913	335	12 16	44 75	44 17	6672	5494	173 30	634			Sealing commenced at 12.30.			
21	-9 17	-9 03	-9 32	-9 18	-9 17	0 00	92 17	84 00	76 00	90 80	77 80	82 40	91 68	12 30	101 77	1031	86	7290	44	2618	894	347	12 16								Sealing finished at 2.00 o'clock and air taken off at 10.00 o'clock.				

Final settlement made at 10.30 o'clock.

Pumping finished at 10.30 o'clock.

Sealing commenced at 12.30.

Sealing finished at 2.00 o'clock and air taken off at 10.15

APPENDIX C.—CONTINUED.
 RECORD OF SINKING CAISSONS.
 PIER V.

Observations taken at 8 o'clock.

Date	Elevations of Cutting Edge					Sinkage		Elevations of Ground					Average		Water Gauge	Water Immersed	Weights										Air Pressure		Inch. Hg. Pressure	Net Weight	Surface Area	Average Weight per Sq. Ft. of surface exposed to friction	Material	REMARKS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	N 1	N 2	S 1	S 2	Average	In 24 Hours	Total	N 1	N 2	S 1	S 2	Average	Per Foot of Casson	Per Foot of Casson			Timber	Casson	Loc. new	Act. Lock	Ma. so. to	Sand	Water	Total	Inch. Hg.	C. Hg.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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APPENDIX C. CONTINUED. RECORD OF SINKING CAISSONS.

PIER V. CONTINUED.

Observations taken at 8 o'clock.

Date	ELEVATIONS OF CUTTING EDGE						ELEVATIONS OF GROUND						Average Depth of Cut		Water Gauge	Depth in feet	Weights				Average Weights				Material	REMARKS	
	S.S.W.						S.W.						Timber				Iron		Tons		Tons						
	N	E	S	W	Other	Notes	N	E	S	W	Other	Notes	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.			
1868																											
Jan 26	49.07	48.82	48.76	48.51	48.70		0.00	34.21	71.80	87.10	87.70	88.70	88.82	33.03	94.00												
" 27	49.07	48.82	48.76	48.51	48.70		0.00	34.31	71.80	86.70	86.80	86.80	86.80	33.01	94.75												
" 28	49.07	48.82	48.76	48.51	48.70		0.00	34.21	71.80	85.30	86.00	85.00	85.82	33.03	94.75												
" 29	48.55	48.55	48.55	48.55	48.55		0.24	34.45	74.50	84.00	86.20	84.20	84.22	33.07	94.00												
" 30	48.55	48.55	48.55	48.55	48.55		0.00	34.45	75.10	82.10	87.70	82.80	81.99	33.07	94.00												
" 31	48.55	48.55	48.55	48.55	48.55		0.00	34.45	75.20	81.70	85.00	82.00	81.27	33.72	94.45												
Feb 1	48.85	48.55	48.55	48.55	48.55		0.00	34.45	74.00	80.00	87.50	81.10	80.90	33.25	94.20												
" 2	48.85	48.55	48.55	48.55	48.55		0.00	34.45	76.10	81.10	86.70	82.10	81.50	33.03	94.90												
" 3	48.85	48.55	48.55	48.55	48.55		0.00	34.45	76.70	81.50	87.00	81.80	81.70	33.15	95.70												
" 4	48.85	48.55	48.55	48.55	48.55		0.00	34.45	78.20	82.10	87.30	84.70	83.07	33.72	96.30												
" 5	48.85	48.55	48.55	48.55	48.55		0.00	34.45	75.10	81.00	87.40	80.00	81.25	33.70	96.50												
" 6	48.85	48.55	48.55	48.55	48.55		0.00	34.45	75.10	80.00	86.80	80.30	80.62	33.67	93.90												
" 7	48.85	48.55	48.55	48.55	48.55		0.00	34.45	76.00	80.00	86.70	80.20	81.02	33.47	93.80												
" 8	48.85	48.55	48.55	48.55	48.55		0.00	34.45	77.00	80.00	86.00	80.40	81.07	33.32	93.85												
" 9	48.85	48.55	48.55	48.55	48.55		0.00	34.45	76.90	80.40	86.00	80.50	81.92	33.77	94.00												
" 10	48.85	48.55	48.55	48.55	48.55		0.00	34.45	77.30	80.80	87.30	80.50	81.47	33.25	94.30												
" 11	48.85	48.55	48.55	48.55	48.55		0.00	34.45	76.40	81.80	87.50	80.80	81.60	33.05	94.20												
" 12	48.85	48.55	48.55	48.55	48.55		0.00	34.45	77.10	79.90	86.70	78.70	80.52	33.97	94.20												
" 13	48.85	48.55	48.55	48.55	48.55		0.00	34.45	78.80	83.30	87.80	80.90	83.05	33.50	95.25												
" 14	48.85	48.55	48.55	48.55	48.55		0.03	34.48	78.50	80.40	88.50	80.40	81.45	33.45	94.45												
" 15	48.85	48.55	48.55	48.55	48.55		0.01	34.49	78.30	80.20	88.50	81.80	83.27	33.70	94.50												
" 16	44.14	48.96	48.85	48.67	48.90		3.81	36.10	75.80	80.50	91.50	78.50	81.05	37.73	96.00	52.10	6.4	7.8	5.22	19							
" 17	40.44	39.97	39.95	38.64	40.03		2.87	48.97	77.30	78.70	95.70	75.70	81.57	41.54	97.10	57.07	6.8	7.9	39.18	19							
" 18	39.38	38.91	38.91	38.61	39.00		1.03	44.10	78.00	78.00	90.00	78.00	80.70	41.50	96.70	57.70	6.9	7.9	39.18	19							
" 19	37.15	36.99	36.83	36.37	36.88		2.14	46.11	75.00	75.00	90.70	77.70	80.60	43.74	96.60	59.10	6.9	7.8	42.48	19							
" 20	35.78	35.07	35.00	34.16	35.03		1.88	47.07	78.00	77.00	87.50	76.30	79.75	44.72	94.50	60.47	6.9	7.8	41.70	19							
" 21	35.38	33.66	33.60	31.68	33.03		2.00	47.97	78.10	75.10	87.50	77.20	78.50	43.87	94.90	59.87	6.9	7.8	43.70	20							
" 22	35.38	33.66	33.60	31.68	33.03		2.00	47.97	78.20	73.20	86.50	73.00	78.05	43.02	94.70	59.67	6.9	7.8	43.07	20							
" 23	35.21	31.84	31.83	31.43	31.84		0.19	48.10	76.40	75.40	90.00	75.00	79.23	44.11	94.60	59.78	7.2	8.1	44.07	20							
" 24	31.01	31.01	31.01	31.01	31.00		2.24	51.50	77.60	74.60	90.00	76.00	79.60	44.10	94.60	63.30	7.5	8.6	44.67	20							
" 25	29.67	29.67	29.35	28.35	29.20		3.31	53.71	74.60	73.60	90.00	72.00	77.55	48.26	97.10	66.11	7.5	8.6	48.68	20							
" 26	28.48	28.99	29.08	25.05	29.05		3.26	56.07	72.80	70.80	84.30	68.30	73.80	47.77	95.85	61.92	7.5	8.6	51.70	22							
" 27	23.05	21.82	21.78	21.20	21.78		4.35	61.23	74.50	70.50	88.40	71.40	75.10	51.81	95.80	71.00	7.5	8.6	51.83	22							
" 28	21.40	21.33	21.39	20.05	21.32		0.36	61.78	74.00	73.00	85.00	71.00	75.00	54.28	96.60	74.08	7.5	8.6	54.09	22							
Mar 1	31.40	31.40	31.40	31.40	31.40		0.18	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.71	7.5	8.6	56.87	22							
" 2	31.40	31.40	31.40	31.40	31.40		0.16	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.67	7.5	8.6	56.67	22							
" 3	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 4	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 5	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 6	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 7	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 8	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 9	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 10	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 11	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 12	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 13	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 14	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 15	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 16	31.40	31.40	31.40	31.40	31.40		0.03	9.86	71.00	75.40	85.00	75.00	76.08	51.54	99.85	75.62	7.5	8.6	56.67	22							
" 17	31.40	31.40	31.40																								

APPENDIX D.—CONTINUED.
TIME, COST AND MATERIALS USED IN FOUNDATIONS.
PIER III.

APPENDIX D.—CONTINUED.
TIME, COST AND MATERIALS USED IN FOUNDATIONS.
PIER V.

DATE	PRINCIPAL FOREMAN	NIGHT FOREMAN	SEF FOREMAN	LOCK TENDERS	PREMIER MEN	LOPERS	LOPERS	SEAR	CANDERS	ART LAD	WICK	COAL FOR HEATING STEEL IN BULLY	WATER MEN	DAY ENGINEER	NIGHT ENGINEER	PUMP MEN	HELPERS	FIREMEN	COAL FOR BOILERS	COAL FOR BOILERS	SIGNAL GUN	BLACK OIL	CYCLIN LUB OIL	WASTE	COAL OIL	TOTALS	REMARKS					
	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days					
1892																																
Dec 21			1	3 00	1 40 54	11 00		15 8 01																								
22			24	10 50	3 00 25	50 00	1 17			30 46				3 30 1	3 32 1	3 32 2	1	2 40 3	4 80 3	4 30 4 5	10 07		21	21		\$ 51 24 0 19	Med cond.	21	Started air pumps at 11:30 o'clock.			
23		3 30		3 00	3 00 24	18 00	3 30		22 1 11	28 48				3 30 1	3 32 1	3 32 2		1 24 3	1 50 2	3 00 8	16 13					105 88 0 18		18				
24				3 00	3 00 24	48 00	3 30							3 30 1	3 32 1	3 32 2		2 40 3	4 80 3	4 30 9	27 01	2	66			119 43 1 78		116	21	Sand pump started at 20:10 o'clock.		
25		2 30		14	4 50	5 00 18	24 00	3 30						3 30 1	3 32 1	3 32 2		2 40 3	4 80 3	4 30 11 7	27 75					123 80 3 31		21	41	Sand pumps stopped at 10:40 o'clock.		
26														3 30 1	3 32 1	3 32 2		2 40 3	4 80 3	4 30 12 2	26 94	2	00			95 50 0 30		21	48	Sand pumps stopped at 10:40 o'clock.		
27			24	7 30	5 00 37	7 00	3 30			9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 3	4 30 7 5	17 79			30	30	67 59 0 00			14			
28				4	1 30	5 00		3 30		7 13				3 30 1	3 32 1	3 32 2		2 40 3	4 80 3	4 30 7 6	15 03	8	31			55 25 0 00			13			
29		2 30		24	7 30	5 00 74	18 00	3 30		10 19				3 30 1	3 32 1	3 32 2		2 40 3	1 50 3	11 0	38 06					58 52 1 44			11	42	Sand pumps started at 20:00 o'clock.	
30		2 50		3	9 00	5 00 35	50 00	3 30	17 8 81	24 44				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 14 0	33 21	2			135 00 0 37			20	42			
31		2 10		3	9 00	5 00 34	18 00	3 30		20 1 02	10 35			3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 18 3	22 02			06	80	1 10	125 08 1 80			19	43	
1908														3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 18 3	22 02					128 98 1 00			11	46	Sand pumps stopped at 21:30 o'clock.	
Jan. 1				2	5 00		3 30			10 19				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 11 2	26 76					62 73 0 04				17		
2				2	5 00		3 30			9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 8 0	21 10					37 24 0 12				17		
3				2	5 00		3 30			9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 8 2	19 45					53 83 0 71				18		
4		3 30		2	6 00	5 00 17	84 00	3 30		17 31				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 11 5	27 88	2	00			106 17 2 51			20	45	Two days from Jan 1st started at 9 40 "low"	
5		2 30		3	9 00	5 00 33	50 00	3 30	14 3 70	26 07				3 30 1	3 32 1	3 32 2		2 40 3	1 50 2	12 0	37 88	2	00			131 38 3 68			22	40	Sand pumps stopped at 8 00 o'clock	
6			2	6 00	5 00 10	32 00	3 30			18 33				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 9 5	22 13					96 00 0 08				24		
7			2	5 00		3 30				8 14				3 30 1	3 32 1	3 32 2		2 40 3	1 50 2	12 0	37 88					31 35 0 00				22		
8			2	5 00		3 30				9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 9 5	22 53					38 44 0 00				23		
9			2	5 00		3 30				9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 9 5	22 53					38 01 0 00				22		
10			2	5 00		3 30				16 30				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 9 5	22 53					38 58 0 00				21		
11			2	5 00		3 30				9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 9 5	22 53					50 44 0 00				23		
12			2	5 00		3 30				9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 8 0	18 97			1 06		55 11 0 00				22		
13			2	4 00						9 16				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 8 0	15 43					41 08 0 00				22		
14			2	4 00						12 32				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 7 18	18 74			10 60		46 00 0 03				22		
15			2	4 00						13 24				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 8 2	18 46					45 79 0 00				22		
16			2	4 00						13 24				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 8 0	16 60					42 93 0 00				22		
17			2	4 00						12 22				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 7 5	17 79					44 00 0 00				22		
18			2	4 00						12 22				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 6 8	16 14					42 44 0 09				22		
19			2	4 00						12 24				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 6 0	14 23					40 54 0 00				22		
20			2	4 00						14 28				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 3 8	9 26					36 13 0 00				18		
21			2	4 00						13 24				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 4 5	10 07	4	13			37 11 0 00				19		
22		3 50		1	3 00	4 00 10	20 00	3 30		12 22				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 10 3	24 19					80 05 4 32			18	49	Sand pumps started at 15:35 o'clock.	
23		5 00	3 30	24	7 30	4 00 264	58 00	1 02		43 80				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 7 3	17 73					119 15 0 01			72	50	Sand pumps stopped at 15:50 o'clock.	
24		3 50		2	4 00					5 08				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 4 2	9 56					41 67 0 02				18		
25		2 50		2	4 00					3 06				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 4 8	11 28	4	13			40 37 0 00				18		
26				2	4 00					4 07				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 4 5	10 08					36 82 0 00				18		
27			2	4 00						3 06				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 4 0						26 12 0 00				17		
28			2	4 00						4 07				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 11 5	27 29			18 11 10	11 84	28 08 0 24				17		
29			2	4 00						13 23				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 7 3	17 80	4				53 29 0 00				16		
30			2	4 00						14 28				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 7 3	17 80	4				43 75 0 00				16		
31			2	4 00						13 23				3 30 1	3 32 1	3 32 2		2 40 3	4 80 2	4 30 7 0	16 60					40 35	43 45 0 00				13	
Forward	37 50	3 30	111 00	200 00	538 00	79 27	10 98	3 14	10 51	15 42	155 00	183 49	135 42	106 30	100 80	301 00	176 40	801 82	1 10	2 56	1 10	2 10	1 05	2580 08								

PIER V.—CONTINUED

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APPENDIX E.

SPECIFICATIONS FOR MASONRY.

GENERAL.

1. The masonry will comprise one abutment and four piers.
2. The piers will be numbered from the St. Louis County shore to the St. Charles County shore, the East or South Abutment being Pier I and the pier next to the St. Charles County bank Pier V.
3. Pier I will be an abutment with square wing walls.
4. Piers II and IV will measure 12 feet thick and 34 feet long between shoulders under the belting course. The ends will be round for the upper 38 feet and pointed below.
5. Pier III will be precisely like Piers II and IV, except that it will be six and one-half inches higher, this difference being added to the round ended portion.
6. Pier V will measure 9 feet thick and 37 feet long between shoulders under the belting course, and will have round ends throughout.
7. Pier I will be built entirely of oolitic limestone from the quarries near Bedford, Indiana. It is estimated to contain approximately 1300 cubic yards.
8. Piers II, III and IV will be built of Bedford limestone except that the face stones of the entire piers for a height of 30 feet below the pointed copings will be granite. Each of these piers will contain approximately 2800 cubic yards of masonry of which approximately 700 cubic yards will be granite.
9. Pier V will be built entirely of Bedford limestone and will contain approximately 1300 cubic yards of masonry.
10. The entire masonry shall be built according to detail plans furnished by the Chief Engineer.

STONE.

11. The face stone must be strong, compact, of uniform quality and appearance and free from any defects which in the judgment of the Engineer may impair its strength or durability. The so called blue stone which does not stand quarrying in the winter shall only be used below the level of the granite work or in backing.
12. No course shall be less than sixteen inches in thickness and no course below the belting course shall be thicker than the one beneath it.
13. Each bed of every stone shall measure at least thirty-six inches in each direction, except that where the thickness of the course is less than twenty-four inches the bed need not exceed one and one-half times the thickness of the stone.
14. The bottom bed shall always be the full size of the stone and no stone shall have an overhanging top bed.

15. Stretchers shall not be less than four feet nor more than seven feet long, and stretchers of the same width shall not be placed together vertically, but this shall not apply to the ends of stretchers where leaders come centrally between stretchers.

16. Headers shall be at least five feet long and shall be at least three-quarters their full width for the whole length. There shall be at least three headers on each side of every course between the shoulders.

17. The backing shall be composed of stones of the same thickness as the face stones, with beds cut in the same manner as required for the face stones and with no overhanging top beds. The spaces between the large stones shall not occupy more than one-fifth of the entire area of the pier inside of the face stones, and these spaces shall be filled with good rubble masonry carefully laid up in full mortar beds and well rammed.

CUTTING.

18. The face lines of each stone shall be true, and the rise as fixed by the face lines shall not vary anywhere more than $\frac{1}{4}$ of an inch from the true rise of the course.

19. The upper and lower beds shall be truly parallel and cut to conform with the requirements for the face lines. Depressions of more than one-quarter of an inch below the true planes shall never exceed one-tenth of the area of the bed.

20. Joints shall be cut vertical and at right angles to the face of the stone unless otherwise shown on special plans. The cutting for at least 12 inches back from the face shall be the same as that required for the beds.

21. Joints shall be broken at least fifteen inches on the face.

22. The vertical joints shall not average more than three-eighths of an inch and shall not exceed one-half inch. Thin, horizontal mortar joints will not be insisted on, but every stone shall be set in a full bed of mortar and settled to a proper bearing, no levelers being allowed.

23. The face of the granite cutwaters of Piers II, III and IV shall be fine pointed work with no projections exceeding one-half inch.

24. The copings, including those over the pointed starlings, shall have the upper surface, wash, face and the lower beds for a width of six inches back bush-hammered with true lines and surfaces. The lower bed of the belting courses shall be bush-hammered to the same extent.

25. The coping shall be cut with close joints throughout the whole pier and according to special plans.

26. A four inch draft line shall be cut on all vertical angles and around the lower edges of the belting course below the coping.

27. All other portions of the piers shall have a rough quarry face with no projections exceeding three inches, the quarry face to average at least one and a half inches from the pitch line of the joints and never to run back of such pitch line.

28. No grab holes shall be made in the face of the coping or on the pointed work of the cutwater.

MORTAR.

29. All face stones shall be laid in Portland cement mortar, two parts of sand to one part of cement. The backing shall be laid in American cement mortar, two parts of sand to one part of cement.

30. When masonry is laid up in freezing weather the backing shall be laid in Portland cement, three parts of sand and one part of cement, and such other precautions taken against freezing as the Engineer may direct.

31. All stones must be carefully cleaned and wet before setting, and no mortar beds shall be laid until the course below has been cleaned and wet.

32. The joints of the face stones shall be cleaned out to a depth of one and one-half inches, and pointed in mild weather with a mortar composed of two parts of sand and one part of Portland Cement, which shall be driven in with a caulking iron.

33. The cement will be furnished by the Railroad Company, but the contractor will be held responsible for all waste or injury to the same.

IRONING.

34. The stones of the curved up stream starlings of Piers II, III and IV shall be dowelled into those of the course below with one and one-eighth inch steel dowels extending six inches into each course, these dowels to be placed about ten inches back from the face and seven inches on each side of each joint. The stones of the upper course shall be drilled through before setting, after which the hole shall be extended six inches into the lower course, a small quantity of mortar shall be put into the hole, the dowel dropped in and the hole filled with mortar and well rammed.

35. The joints in the three courses below the coping in all piers shall be cramped with cramps of one-inch round iron sixteen inches long, the ends put four inches into each stone.

APPENDIX E. (CONTINUED).

TERMS.

36. The foundations will be prepared by the Railroad Company.
37. Pier I will be founded on rock above the level of high water. The necessary excavation will be made and the foundation leveled up with concrete by the Railroad Company.
38. Piers II, III, IV and V will be founded on pneumatic caissons, and the contractor will be required to lay this masonry as the sinking proceeds and to accommodate his tools and machinery to the requirements of the pneumatic work.
39. The contractor will be required to do without charge whatever hoisting may be required at the pier in placing or removing the shafts and locks used in the pneumatic work while masonry is being laid.
40. Preparations must be made on the supposition that one of the three piers II, III and IV will be ready for masonry on August 1, 1892, that another will be ready six weeks thereafter and that the third will be ready by November 1, 1892.
41. The contractor must be prepared to lay at least two courses daily while the sinking is in progress and will be responsible for any delays due to his inability to lay up the masonry at this rate.
42. The contractor must be prepared to begin work on Pier V on January 1, 1893, and to begin work on the east abutment not later than March 1, 1893.
43. Piers II, III and IV shall be finished in the order which the Engineer

may direct, and the entire masonry of the bridge shall be completed on or before May 1, 1893.

44. The contractor shall provide a stone yard near the north end of the bridge in St. Charles county and shall begin the delivery of stone at this yard as early as possible and shall have a sufficient amount of stone to complete the granite work of Piers II, III and IV delivered at this yard on or before August 1, 1892.

45. The contractor shall furnish all tools, machinery and materials of every kind except cement, and complete the masonry ready to receive the superstructure.

46. No work shall be paid for which does not form a part of the permanent structure.

PAYMENTS.

47. Monthly payments shall be made to the contractor on or about the middle of each month. These monthly payments shall be based on approximate estimates made of the work performed up to the end of the preceding month, ten per cent. being held back till completion of contract.

48. In these estimates material delivered ready for use but not yet in place in the permanent structure shall be estimated at the following prices:

Limestone, including backing, cut, delivered and unloaded, ten dollars (\$10) per cubic yard.

Granite cut, delivered and unloaded, twenty dollars (\$20) per cubic yard.

MISCELLANEOUS.

49. No free transportation will be furnished by the railroad nor will any tools be supplied by the Railroad Company.

50. Wherever the word Engineer is used in these specifications, it is understood to be the Chief Engineer of the work. In the absence of the Chief Engineer the Resident Engineer will be considered as his representative and instructions coming from the Resident Engineer will be considered equivalent to those given by the Chief Engineer.

51. All elevations mentioned in these specifications are referred to a datum 100 feet below the St. Louis city directrix.

52. In general it is understood that the work is to be done in a first-class manner and that wherever these specifications admit of a doubt the interpretation which makes the best work shall be followed.

GEORGE S. MORISON,
Chief Engineer.

March 4, 1892.

APPENDIX F.

SPECIFICATIONS FOR SUPERSTRUCTURE.

A.—GENERAL DESCRIPTION.

1. The Superstructure will consist of four spans, 440 feet each, all built for double track, the trusses being placed 30 feet between centers. Each truss will be divided into eight panels of 55 feet each and will be 55 feet deep between centers. The floor will be divided into sixteen panels of 27 feet 6 inches each, the intermediate floor beams being suspended from the middle of each panel.
2. Each span is estimated to weigh approximately 2 800 000 pounds, including fences and bearings.
3. The entire structure will be of M steel, subject to the provisions of the Specifications permitting the use of HM and MS steel in details. Rivets, fences and the lateral rods of the floor system will be of S steel.
4. The expansion and fixed bearings may be of forged Bessemer steel, except such parts as are specified to be of cast steel.
5. The entire structure will therefore be of steel of one kind or another.
6. Full detail plans showing all dimensions will be furnished by the Chief Engineer. The work shall be built in all respects according to these plans and similar plans will be furnished to the inspector. The use of these plans will not relieve the contractor from the responsibility of correcting errors, provided those errors are of a manifest character which could be discovered by a careful inspection of the plans.
7. Should the contractor desire to make his own shop plans, they will be for his use only, and he will be held responsible for any variations between such plans and those furnished by the Engineer.

B.—STEEL.

CLASSES.

1. Steel will be divided into four classes: HM, M, MS and S, of which M and S will be standards, and HM and MS intermediates.
2. Class M will be known as Medium Steel and will be used in those portions of every member which constitute the calculated section.
3. Class S will be known as Soft Steel and will be used for rivets, fences and the lateral rods of the floor system.
4. HM and MS steel will be accepted for details and parts which do not form portions of the calculated sections.

MANUFACTURE.

5. Steel shall be made by the open hearth process, and no steel shall be made at works which have not been in successful operation for at least one year; but this

provision shall not be held to exclude new furnaces erected in connection with old works.

6. If made in an acid furnace, the amount of phosphorus in the finished product shall never exceed eight one-hundredths of one per cent, this being a maximum and not an average requirement.

7. If made in a basic furnace, the amount of phosphorus shall never exceed four one-hundredths of one per cent, this being a maximum and not an average requirement, and being considered necessary to show a proper amount of work in the furnace.

8. The finished product shall be perfect in all parts and free from irregularities and surface imperfections of all kinds. All steel must be free from piping.

9. The cross sections shall never differ more than $2\frac{1}{2}$ per cent. from the ordered cross sections as shown by the dimensions on the plans.

10. Steel for pins more than four inches in diameter shall be hammered.

11. Every finished plate, bar or angle shall be stamped on one side, near the middle, with a number identifying the melt, and this stamp shall be surrounded with a heavy circle of white paint. Steel for pins shall have the melt numbers stamped on the ends. Rivet steel and small pieces which do not form part of the calculated section of members may be shipped in bundles, wired together, with the melt number on a metal tag attached.

TESTS

12. A sample bar not more than two inches wide, and having a cross section of one square inch when the material is not less than one-half inch thick, shall be cut from the finished product of every melt. When taken from metal more than two inches thick this sample may be a turned, round bar. The laboratory tests shall be made on this sample bar in its natural state without annealing.

13. When a melt is rolled into several varieties of material, each variety shall be separately tested. A variety shall consist entirely of one of the following shapes: Sheared Plates, Universal Mill Plates, Angles, Z's, Channels, I beams, Flats, Rounds, Squares, Pin Steel and Eyebar Steel. Flats will include all flats not intended to be forged into eyebars. Where several sizes of the same variety are rolled, the cross section of the largest size shall not be more than twice that of the smallest size, and the sample shall be taken from the size which comes nearest to a mean.

14. In the laboratory tests, measurements to determine elongation shall be made on a length of eight inches.

15. A piece of each sample bar shall be bent 180 degrees and closed up against itself. In no case shall any crack appear until the circle around which the bar is

bent becomes less than the thickness of the bar. Except when the sample is taken from a pin, the sample bar shall close up against itself without showing any crack or flaw on the outside of the bent portion.

16. The sample bar shall be tested in a lever machine and the following requirements fulfilled:

	CLASS OF STEEL			
	HM.	M.	MS.	S.
Ultimate Strength, lbs. per square inch	70 000	66 000	62 000	58 000
Elastic Limit, " " " "	35 000	33 000	31 000	29 000
Percentage of Elongation in 8 inches..	18	22	24	26
" " Reduction at Fracture..	36	44	48	52

17. Where the sample is taken from a pin, the elongation and reduction will be reduced to 15 and 30 per cent. for the HM steel and to 18 and 36 per cent. for the M steel.

18. The entire fracture shall be silky.

19. The requirements for ultimate strength are means, and steel will be accepted when the ultimate strength does not differ more than 4000 lbs. from the requirements of the table.

20. The requirements for elastic limit, elongation and reduction are minimum requirements, and no steel will be accepted which falls below these conditions.

21. The elastic limit will be observed by the falling of the beam of the testing machine.

22. Duplicate tests may be made when the first sample tested fulfills four of the five requirements. If the second test and also the average of the two tests meet all the requirements, the melt may be accepted. Cases in which the tests are thought not to give fair indications of the character of the material, shall be referred to the Engineer.

23. Analyses shall be made showing the amount of phosphorus and carbon in every melt, the drillings for these analyses being taken directly from one of the ingots. Besides this, a set of analyses of phosphorus, carbon, silicon and manganese shall be made from every ten melts, the drillings to be taken from a sample test bar.

INSPECTION.

24. The mill inspection shall be performed at the expense of the manufacturer by an inspector accepted by the Engineer. It will be the duty of this inspector to send the notices required below.

25. The acceptance of material by such inspector will not be considered final, but the right is reserved to reject material which may prove defective or objectionable at any time during manufacture and erection.

APPENDIX F.--CONTINUED.

26. Two notices of the acceptance of each melt shall be mailed on the day of such acceptance, stating the number of the accepted melt and quality of steel. One of these notices shall be sent to the Engineer and one to the shop inspector.

27. Two notices of the shipment of manufactured material, identifying the melts and dimensions, shall be mailed on the day after such shipments are made, in the same manner as the notices of the acceptance of material.

28. Weekly reports in full detail, including reports of chemical analyses, for whatever reason made, and certified by the mill inspector, shall be sent to the Engineer not later than the end of the week succeeding the week in which such tests are made.

D.--GENERAL SHOP REQUIREMENTS.

1. The work shall be done in all respects according to the detail plans furnished by the Engineer.

2. Where there is room for doubt as to the quality of work required by the plans or specifications, the doubt shall be decided by using the best class of work which any interpretation would admit of.

3. All workmanship, whether particularly specified or not, must be of the best kind now in use. Past work done for the same Engineer will never be recognized as a precedent for the use of other than the best kind of work.

4. All material shall be cleaned, and if necessary, scraped, and given one heavy coat of Cleveland Iron Clad Paint, purple brand, put on with boiled linseed oil before shipment. This applies to everything except machine-finished surfaces.

5. The same paint shall be used wherever painting is required.

6. All machine surfaces shall be cleaned, oiled and given a heavy coat of white lead and tallow before shipment. The inspector must see that this is a substantial coat, such as is used on machinery, and not a merely nominal covering.

7. All small bolts, all pins less than six inches in diameter, the expansion rollers and everything with special work on it, shall be carefully boxed before shipment.

E.--RIVETED WORK.

1. All plates, angles and shapes shall be carefully straightened at the shop before they are put together; mill straightening will not be considered as meeting this requirement.

2. If the rivet holes are marked from templates, these templates shall lie flat without distortion when the marking is made.

3. The size of rivets shown on the plans is the size of the cold rivet before heating.

4. The diameter of the finished rivet hole shall not be more than $\frac{1}{16}$ inch greater than the diameter of the cold rivet. The heated rivet shall not drop into

the hole, but require a slight pressure to force it in; the relative size of the rivet and rivet hole must be such as to meet this requirement.

5. In all cases where riveting is to be done in the field, the parts so to be riveted shall be fitted together in the shops and the rivet holes reamed out while they are so assembled, or an iron templet at least one inch thick shall be made and both parts reamed to fit this templet.

6. All surfaces in contact shall be cleaned and painted before they are put together.

7. The rivets shall be driven by power wherever this is possible. The manufacturer will be required to procure special riveting machines to meet special positions. This applies especially to four web chords.

8. All rivets shall be regular in shape, with hemispherical heads concentric with the axes, absolutely tight, and shall completely fill the holes. Tightening by calking or recutting will not be allowed. This applies to both power driven and hand-driven rivets.

9. The angles of stringers must be square and straight. The web-plate must not project above the angles, and the outside edges of the top angles must never be above a true plane and never more than $\frac{1}{16}$ inch below a true plane coincident with the roots of the angles.

10. The outside angle at the root of the angles connecting stringers with floor beams, floor beams with posts, or in other like details, shall never be less than a right angle, and the excess over a right angle shall never be greater than $\frac{1}{4}$ inch in the longer leg of the angle; the angle shall be perfectly straight.

11. These angles shall be so fitted that the length, measured to the root of any one of the angles, does not vary more than $\frac{1}{16}$ inch from the true length. The effect of these requirements will be to prevent more than $\frac{1}{16}$ inch reduction of area at the root of the angle by facing and to secure a true surface for the whole width of the connection, which will require no strain in the rivets to draw the parts together.

12. All sheared or rough edges shall be carefully planed off.

13. The material may be punched with holes $\frac{1}{16}$ inch smaller than the size of the rivets shown on the plans, except as provided below.

14. When the thickness of the metal is greater than a thickness $\frac{1}{4}$ inch less than the diameter of the rivet, the punched hole shall be $\frac{1}{16}$ inch smaller than the diameter of the rivet.

15. When the thickness of the metal is greater than a thickness $\frac{1}{2}$ inch more than the diameter of the rivet, no punching will be allowed, but the holes must be drilled.

16. After the several pieces have been punched, or drilled, they shall be assembled. The holes shall then be reamed to the diameter required by the size of the rivets, while the pieces are together.

17. After reaming, every hole shall be entirely smooth, showing that the reaming tool has everywhere touched the metal. In special cases where this fails, the Engineer may authorize the hole to be reamed to a larger size and larger rivets used.

18. A reamer shall be run over the outer edges of every hole so as to remove the sharp edges and make a fillet of at least $\frac{1}{16}$ inch under each rivet head.

19. After the reaming is completed the several pieces shall be taken apart and cleaned.

20. The surfaces in contact shall then be painted, the parts assembled while the paint is fresh and riveted up according to the foregoing requirements.

21. The fences which are made of S steel may be punched and riveted without reaming.

F. -FORGED WORK.

1. The heads of eyebars and enlarged screw-ends shall be formed by upsetting and forging into shape by a process acceptable to the Engineer. No welds will be allowed.

2. After the working is completed, the bars shall be annealed in a suitable annealing furnace by heating them to a uniform dark red heat and allowing them to cool slowly.

3. The form of the heads of steel eyebars may be modified by the contractors to suit the process in use at their works, but the thickness of the head shall not be more than $\frac{1}{16}$ inch greater than that of the body of the bar, and the heads shall be of sufficient strength to break the body of the bar.

4. Eyebars shall be bored truly and at exact distances, the pin-holes to be exactly on the axis of the bar and at exactly right angles to the planes of the flat surfaces.

5. When six bars of the same billed length are piled together, the two pins shall pass through both pin-holes at the same time without driving. Every bar shall be tested for this requirement.

6. Pin-holes shall be bored with a sharp tool that will make a clean, smooth cut. Two cuts shall always be taken, the finishing cut never to be more than $\frac{1}{16}$ inch. Roughness in pin holes will be sufficient reason for rejecting bars.

7. The full number of bars of each billed size shall be made at one time, and one more bar shall be made than the number required for the structure. When the bars are finished, one bar of each lot shall be selected by the inspector for testing. This will require 14 full-size test bars in all.

8. No bars known to be defective in any way shall be taken for test bars, but the bars shall be selected as fair average specimens of the good bars which would be accepted for the work.

9. The test of full size eyebars shall be made in the large testing machine at Athens, Pa., unless some other machine is specially accepted by the Engineer.

10. These bars will be required to develop an average stretch of twelve per

APPENDIX F.—CONTINUED.

cent., and a minimum stretch of ten per cent. before breaking. The elongation shall be measured on a length of not less than twenty feet, including the fracture.

11. The bars will be required to break in the body.

12. They shall also show an elastic limit of not less than 32 000 pounds, and an ultimate strength of not less than 60 000 pounds, as indicated by the registering gauges of the testing machine at Athens.

13. In case of bars too long for the machine, the test bar shall be selected before the bars are annealed; the bar selected shall then be cut in two, each half shall be reheated, and both halves shall be annealed, bored and tested, the two tests, however, to count as a single bar.

14. In the test of full-size bars, a failure to meet the required elongation will be considered fatal and be a sufficient cause for condemning the bars represented by the bar so tested; but the engineer shall examine carefully into the cause of the breakage of any bar which does not meet the requirements and may order additional tests if he sees fit.

15. When a bar breaks in the head, but develops ten per cent. elongation before breaking, a second bar shall be selected from the same lot of bars. If this bar breaks in the body, and the two bars develop the average stretch of twelve per cent., the bars of this lot may be accepted; provided, however, that if more than one-third of the total number of bars tested break in the head, the entire bill of cye-bars may be rejected.

G.—MACHINE WORK.

1. The planing, drilling and reaming required under the provisions for riveted work shall always be performed.

2. The ends of the chord sections shall be faced so as to be perfectly true after they are riveted up complete, excepting only the projecting splice plates. A special riveting machine will be required to rivet on the splice plates of the four web chords after facing.

3. When four chord pieces are fitted together complete in the shop, there shall be no perceptible wind in the length of the four sections.

4. All chord sections shall be stamped at each end on the outside with letters and numbers designating the joints in accordance with a diagram furnished by the Engineer.

5. All pin-holes and holes for turned bolts passing through the whole width of a riveted member, shall be bored or drilled after all other work is completed.

6. Pin-holes shall be bored truly and at exact distances, parallel with one another, and at exactly right angles to the axis of the member.

7. Pin-holes shall be bored with a sharp tool which will make a clean, smooth cut. Two cuts shall always be taken, the finishing cut never to be more than $\frac{1}{8}$ inch. Roughness in pin-holes will be sufficient reason for rejecting a whole member.

8. Pin-holes shall be bored to fit the pins with a play not exceeding $\frac{1}{16}$ inch. These requirements apply to lateral connections as well as to other pins.

9. The plans show the distance between the centers of pin-holes. Shop measurements shall be made between the bearing edges of tension or compression members, with a proper allowance for the diameter of the pin. An iron standard of the same temperature as the piece measured shall always be used.

10. All pins shall be accurately turned to a gauge and shall be of full size throughout.

11. The ends of stringers and of floor beams shall be squared in a facer, as shall also all other similar connections.

12. All bearing surfaces shall be truly faced.

13. All surfaces so designated on the plans shall be planed.

14. All screws cut on steel shall have a truncated V thread, United States standard, eight threads to the inch.

H. BEARINGS.

1. The EXPANSION BEARING will consist of five parts: 1, the Base Plate; 2, the Rollers; 3, the Bearing Plate; 4, the Rocker Plate; 5, the Top Plate.

2. The FIXED BEARING will consist of three parts: 1, the Support; 2, the Rocker Plate; 3, the Top Plate. The Rocker Plate and the Top Plate will be precisely like the Rocker Plate and the Top Plate of the Expansion Bearing.

3. The Base Plate will consist of a plate 14 in. thick, to which are riveted a number of steel rails, these rails to be Pennsylvania Steel Company, Section 78, 5 in. high, with heads 24 in. wide, the rails placed 3 in. between centers. The base of the rails shall be planed off in the manner shown on the plan and the rails riveted to the plate. The bottom of the plate shall then be planed, after which the plate shall be placed on a planer and the tops of the rails and the outside faces of the two outside heads shall be planed. The top bearing surface shall then be polished to such an extent that the tool marks cannot be seen. The side edges of the bottom plate shall also be planed.

4. The Rollers will be of forged steel. The ends and parallel sides shall be planed. The rolling surfaces shall be turned and polished. The hollow faces of the sides may be left rough. The pins at the ends of the rollers shall be screwed into the rollers and keyed with a $\frac{1}{4}$ in. key 14 in. long, the key seat being bored through the threads of the screw. The side plates shall be drilled to fit the pins with a play not exceeding $\frac{1}{16}$ in. All screws on pins shall have truncated V threads, eight threads to the inch.

5. The Bearing Plate shall be of cast steel. The side edges shall be planed, and the bearing surface shall be planed and polished. When this surface is finished, there shall be no blow-hole visible exceeding one inch in either dimension, nor exceeding one-half square inch in area. The length of blow-holes cut by any straight

line laid in any direction, shall never exceed one inch in any one foot. The hollow cylindrical surface of the socket shall be turned true and polished; there shall be no blow or sand hole on this surface exceeding one-half an inch in either direction, nor exceeding one-sixteenth square inch in area, and the total area of holes shall not exceed two per cent. of the entire surface; the sides of the socket shall be turned true.

6. The Rocker Plate shall be a steel forging. The four sides shall be planed and fit the sides of the socket within $\frac{1}{16}$ inch; the cylindrical surfaces shall be turned and polished to fit the corresponding surfaces of the sockets exactly.

7. The Top Plate shall be a steel casting, the upper surface being planed and having the same requirements as to blow-holes as the lower surface of the Bearing Plate. The hollow socket shall be subject to the same requirements as the socket of the Bearing Plate.

8. The Support will be a steel casting. The bottom shall be planed and the requirements as to blow-holes shall be the same as for the bottom of the Bearing Plate of the Expansion Bearing. The requirements for the socket shall also be the same.

9. The Base Plate, the Rollers including side plates, and the Rocker Plate, may be of Bessemer steel of the same quality as the best Bessemer rail steel, the finished pieces to be free from all surface defects and entirely free from piping.

10. Every steel casting shall be cast with a coupon for testing, which coupon shall be cut off after annealing, and the test shall be made on a $\frac{1}{2}$ in. round turned from this coupon. When tested this test piece shall show an ultimate strength of at least 70 000 lbs., an elastic limit of at least 40 000 lbs., an elongation of at least 15 per cent. in two inches and a reduction of 20 per cent. at the point of fracture.

11. The workmanship shall all be first-class, and when the bearing is set up there shall be no visible break of contact between the polished surface of the rollers and that of the plates, either above or below.

I.—ERECTION.

1. The Chicago, Burlington and Quincy Railroad will transport the material from Chicago to the bridge site, delivering it on a side track where it can be unloaded conveniently on the north side of the river. No other transportation or switching will be furnished.

2. The contractor will be expected to receive all material as it arrives on the cars, to unload this material and store it in a material yard until ready for erection.

3. He will be held responsible for the custody and care of all superstructure material after its arrival.

4. A track will be laid to a convenient position for unloading material and no switching will be done after the material has once been unloaded.

5. The contractor will be required to keep all the material in good condition,

APPENDIX F.—CONTINUED.

and in case of its becoming dirty or rusty, will be expected to clean it before erecting.

6. The contractor will be required to paint all surfaces which will be inaccessible for painting after erection, the paint being furnished by the Railroad Company.

7. The contractor will be required to furnish all tools, barges and false work of every description.

8. The contractor will be required to remove all work which he may put in the river, so that there will be nothing left either to interfere with navigation or to catch drift.

9. No holes shall be drilled or bolts placed in the piers without the express permission of the Engineer. All bolts so put in shall be removed and the holes carefully filled with Portland cement mortar, and any damages done shall be charged to the contractor.

10. The setting of the wall plate castings, including the drilling of holes in masonry for the anchor bolts, the packing of rust cement under the castings, if used, and all other work connected therewith is to be done by the contractor.

11. The contractor will be required to erect the superstructure complete in every respect including riveting ready to receive the timber floor.

12. The erection shall include the placing and riveting of the fence and the ladders over the piers.

13. The provisions as to riveting given under the head of RIVETED WORK, will apply to riveting done during erection.

14. Rivets connecting the floor beams with the posts shall be driven by power, and, if necessary, the contractor must procure a special machine for this purpose.

K. TERMS.

1. The work will be paid for by the pound of finished work loaded on cars and delivered to the Chicago, Burlington & Quincy Railroad, at Chicago, the cars to go through without transfer at Chicago.

2. No material will be paid for that does not form a part of the finished structure.

3. All cost of testing shall be borne by the contractor.

4. The contractor will be required to furnish the field rivets for erection, furnishing twenty per cent. in excess of each size over and above the number actually required, but this excess will not be estimated, but considered as taking the place of the work which is not done on these rivets. The contractor for erection will be required to provide whatever rivets may be needed in excess of this surplussage.

5. The contractor will be required to furnish pin pilots, two for each size of pin, these pin pilots to be paid for at the same price per pound as the rest of the work and to belong to the Railroad Company.

6. Approximate estimates shall be made at the end of each month of material received and work performed up to that time.

7. In these estimates material received at the shops but not manufactured, will be estimated at 60 per cent. of the contract price for finished material.

8. Material manufactured but not shipped shall be estimated at 80 per cent. of the contract price.

9. Material completed and shipped shall be estimated at the full contract price.

10. The erection shall be paid for at a fixed price per span, no estimate to be made on account of any span until that span is self-sustaining.

11. Payments shall be made on or about the middle of each month, on the

basis of the estimates made of work performed up to the end of the preceding month, deducting therefrom ten per cent., which will be held as security until the completion of the entire contract.

12. The four several spans shall be delivered complete in Chicago on or before the following dates:

First Span.....	January 1st, 1893.
Second Span.....	February 1st, 1893.
Third Span.....	July 1st, 1893.
Fourth Span.....	August 1st, 1893.

13. It is expected that the masonry will be ready for the first span on or before January 1st, 1893; for the second span on or before February 1st, 1893; and for the other two spans on or before July 1st, 1893.

14. The erection shall follow the delivery of the material, if the river is in a suitable condition to permit of it, and the entire erection shall be completed so that the track can be laid across the bridge on or before October 15th, 1893.

15. These dates are of the essence of the contract, and no monthly estimates will be paid to the contractor while he is in arrears in deliveries or erection; and in case of the failure of the contractor to have the work completed so that the track can be laid across the bridge by October 15th, 1893, he will be held responsible for all expenses and other damages which the railroad company may be put to by reason of such delay.

May 23d, 1892.

GEO. S. MORISON,
Chief Engineer, St. Louis Extension.

APPENDIX G.

TEST OF STEEL EYE BARS.

REMARKS	TESTS ON FULL SIZE EYE BARS										TESTS ON SAMPLE BARS FROM SAME MILLS										KIND OF STEEL	MADE BY	FURNACED BY	TESTED BY		
	JANES ON, INCHES					REDUCED OF MECHANICAL TEST					TESTS ON SAMPLE BARS FROM SAME MILLS															
	Original		Actual		After Test	Reduction of Area	Elongation	Elastic Limit	Max. Load	Place of Fracture	Net Weight	Area		Reduction	Elongation	Elastic Limit	Max. Load	Phos. Per Cent.								
	Nominal	Actual	Length	Width								Thickness	Original						After Reduc.	Original					After Reduc.	
Bar 38.86 ft. long cut in two pieces, first half.....	7	1 1/2	136.36	.98	7.12	1.08	5.75	0.81	38.3	10.6	11.1	37 083	73 389	Body.	70 280	1.203	.649	40.1	39.4	39 906	68 081	.010	Basin Open Hearth	Carnegie Steel Co.	Keystone Bridge Wks.	Keystone Bridge Wks.
second half.....	7	1 1/2	329.59	.904	7.18	1.08	.....	.....	.....	.....	.....	.....	.....	Flare at head	70 351	1.116	.339	51.7	37.5	39 903	62 103	.016	"	"	"	"
Bar 38.87 ft. long cut in two pieces, first half.....	7	1 1/2	339.93	.904	7.03	1.35	.....	.....	.....	.....	.....	.....	.....	Body	70 333	1.150	.068	47.1	30.0	39 701	64 870	.021	"	"	"	"
second half.....	10	2	339.97	.192	10.15	2.00	7.63	1.40	47.0	37.0	19.9	32 470	49 380	"	8 854	1 307	.670	45.7	30.0	38 640	65 110	.048	"	"	"	Union Bridge Co.
Bar 38.87 ft. long cut in two pieces, first half.....	10	1 1/2	329.37	.84	10.15	2.00	8.10	1.33	39.0	29.0	23.8	33 650	60 380	"	"	"	"	"	"	"	"	"	"	"	"	"
second half.....	10	1 1/2	329.37	.192	9.97	1.73	8.12	1.39	33.3	20.0	13.3	33 650	60 040	"	618 090	1 193	.529	53.3	31.2	39 780	62 390	.021	"	"	"	"
Bar 38.88 ft. long cut in two pieces, first half.....	7	1 1/2	341.47	.904	7.07	1.06	5.88	0.76	43.4	42.1	20.6	33 650	61 810	"	70 300	1.353	.653	52.8	31.2	38 370	62 040	.024	"	"	"	"
second half.....	7	1 1/2	329.47	.904	7.07	1.06	5.88	0.76	43.4	42.1	20.6	33 650	61 810	"	70 300	1.353	.653	52.8	31.2	38 370	62 040	.024	"	"	"	"
Bar 48.88 ft. long cut in two pieces, first half.....	10	1 1/2	328.77	.904	10.06	1.73	7.95	1.32	26.7	40.0	33.8	25 660	60 010	"	70 256	"	"	"	"	"	"	"	"	"	"	"
second half.....	10	1 1/2	328.77	.84	10.06	1.73	8.17	1.36	26.9	29.1	23.9	23 970	67 181	"	"	"	"	"	"	"	"	"	"	"	"	"
Bar 47.15 ft. long cut in two pieces, first half.....	9	1 1/2	329.07	.192	9.60	1.83	6.82	0.88	40.7	18.6	25.3	33 540	61 840	"	70 308	1.471	.497	53.6	28.7	40 150	63 030	.026	"	"	"	"
second half.....	9	1 1/2	327.12	.192	9.63	1.23	7.00	0.92	43.0	39.9	30.8	33 780	61 970	"	"	"	"	"	"	"	"	"	"	"	"	"
Bar 54.97 ft. long cut in two pieces, first half.....	10	1 1/2	376.97	.904	10.04	1.93	9.07	1.08	21.3	40.4	16.9	30 240	68 710	"	70 290	1.203	.616	46.1	29.4	39 766	68 060	.010	"	"	"	"
second half.....	10	1 1/2	369.47	.904	10.08	1.29	9.06	0.67	48.7	45.7	18.9	31 910	66 000	"	70 237	1.430	.750	45.0	28.0	38 350	62 530	.019	"	"	"	"
Bar 54.97 ft. long cut in two pieces, first half.....	10	2 1/2	384.17	.240	10.05	2.33	7.8	2.24	4.8	10.9	4.7	38 310	21 810	Not broken.*	11 745	1.445	.736	44.9	21.0	31 650	67 200	.021	"	"	"	"
second half.....	10	2 1/2	283.17	.240	10.03	2.34	8.82	2.28	4.7	10.0	4.2	38 081	62 300	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 54.97 ft. long cut in two pieces, first half.....	10	2 1/2	381.17	.240	10.05	2.64	8.85	2.36	4.6	9.8	3.9	30 480	47 070	"	"	"	"	"	"	"	"	"	"	"	"	
Above piece painted for 10 ft. to area equivalent to 75 per cent. of original.	10	2 1/2	323.25	.908	9.74	2.34	5.30	1.68	43.1	14.8	11.1	30 480	61 110	Broken in plane section.	70 272	1.321	.679	48.8	38.9	39 500	63 780	.011	"	"	"	"
Bar 53.97 ft. long cut in two pieces, first half.....	10	2 1/2	380.77	.240	10.09	2.64	8.85	2.36	4.6	9.8	3.9	31 410	47 030	"	"	"	"	"	"	"	"	"	"	"	"	
second half.....	10	2 1/2	268.47	.228	10.01	2.50	6.80	2.18	4.8	9.0	3.9	31 310	48 800	"	"	"	"	"	"	"	"	"	"	"	"	
Above piece planned for 10 ft. to area equivalent to 75 per cent. of original.	10	2 1/2	378.77	.198	9.97	2.40	9.33	1.90	44.0	23.1	16.1	31 210	63 330	Broken in plane section.	70 288	1.258	.678	40.1	38.0	39 350	64 220	.011	"	"	"	"
Above piece planned for 10 ft. to area equivalent to 75 per cent. of original.	10	2 1/2	309.97	.198	9.99	2.40	9.33	1.90	44.0	23.1	16.1	31 210	63 330	Broken in plane section.	70 288	1.258	.678	40.1	38.0	39 350	64 220	.011	"	"	"	"
Bar 52.97 ft. long cut in two pieces, first half.....	10	2 1/2	389.97	.228	10.04	2.28	8.82	2.31	4.8	8.4	3.7	30 890	48 380	Not broken.*	70 265	1.270	.667	47.9	28.7	37 710	63 700	.009	"	"	"	"
second half.....	10	2 1/2	387.17	.228	10.02	2.27	8.85	2.31	4.7	11.0	4.1	30 900	48 380	Broken in plane section.	"	"	"	"	"	"	"	"	"	"	"	
Bar 38.87 ft. long cut in two pieces, first half.....	10	2 1/2	328.67	.181	10.09	2.63	8.88	2.22	4.0	6.1	3.2	29 520	46 170	"	11 048	1.242	.667	47.7	27.0	41 080	63 900	.014	"	"	"	"
second half.....	10	2 1/2	321.37	.181	10.09	2.63	8.90	2.27	3.9	8.1	3.1	29 050	45 740	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 38.87 ft. long cut in two pieces, first half.....	10	2 1/2	328.37	.192	10.00	2.33	9.70	2.26	6.7	11.6	6.0	31 070	59 440	"	70 288	1.338	.729	45.3	33.7	38 640	63 570	.016	"	"	"	"
second half.....	10	2 1/2	330.47	.184	10.00	2.33	9.76	2.29	4.9	4.1	3.1	31 350	49 300	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 52.97 ft. long cut in two pieces, first half.....	10	2 1/2	387.36	.210	10.08	2.37	7.80	1.73	4.8	8.9	2.9	32 120	60 600	Body.	70 256	1.610	.533	45.3	23.9	40 000	67 910	.029	"	"	"	Union Bridge Co.
second half.....	10	2 1/2	362.73	.210	10.06	2.37	7.86	1.78	4.8	8.9	2.9	32 120	60 600	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 52.97 ft. long cut in two pieces, first half.....	10	2 1/2	381.45	.240	10.08	2.47	8.10	1.88	3.8	30.1	12.2	32 380	67 400	"	70 256	1.788	.855	61.2	27.0	39 780	67 420	.003	"	"	"	"
second half.....	10	2 1/2	390.33	.240	10.06	2.37	7.83	1.89	3.9	31.9	13.0	31 370	64 140	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 54.97 ft. long cut in two pieces, first half.....	10	2 1/2	380.05	.212	10.09	2.31	7.70	1.59	17.5	35.1	11.1	31 670	61 830	"	8 884	1.235	.681	44.1	28.9	38 890	66 110	.007	"	"	"	"
second half.....	10	2 1/2	344.97	.294	10.09	2.31	7.78	1.70	43.2	36.7	13.9	32 550	63 490	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 54.97 ft. long cut in two pieces, first half.....	10	1 1/2	389.35	.294	10.06	1.38	7.95	0.65	40.3	39.3	13.5	33 650	61 980	"	70 238	1.784	.709	13.4	28.1	37 870	64 600	.019	"	"	"	Union Bridge Co.
second half.....	10	1 1/2	362.73	.294	10.06	1.38	7.90	0.54	38.2	38.2	13.5	33 650	61 980	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 48.87 ft. long cut in two pieces, first half.....	10	2 1/2	323.25	.902	9.74	2.63	.....	.....	.....	.....	.....	.....	.....	Body in flare at grip marks.	9 910	1.117	.751	59.1	29.0	41 560	69 010	.038	"	"	"	"
second half.....	10	2 1/2	329.19	.912	10.06	2.91	7.80	1.98	41.6	35.5	14.1	31 320	61 390	Body.	"	"	"	"	"	"	"	"	"	"	"	
Bar 54.97 ft. long cut in two pieces, first half.....	10	2 1/2	382.67	.240	10.02	2.39	7.88	1.78	39.9	31.3	13.0	31 090	61 890	"	14 215	1.615	.738	45.0	22.0	40 780	67 190	.019	"	"	"	Keystone Bridge Wks.
second half.....	10	2 1/2	370.28	.241	10.00	2.39	7.81	1.73	40.1	29.7	20.0	33 360	61 890	"	"	"	"	"	"	"	"	"	"	"	"	
Bar 54.97 ft. long cut in two pieces, first half.....	10	1	389.10	.240	10.01	2.11	9.74	1.18	10.8	22.3	9.3	36 700	68 900	Body (slight flaw).	11 198	.010	.530	14.7	37.0	40 000	67 030	.017	"	"	"	"
second half.....	10	1	387.4	.240	10.02	1.23	9.18	0.96	37.3	43.8	18.2	37 600	71 000	Body.	"	"	"	"	"	"	"	"	"	"	"	
Bar 54.97 ft. long cut in two pieces, first half.....	7	1 1/2	389.97	.294	7.00	1.57	Area = 7.67	.....	41.1	35.7	15.6	39 060	67 550	"	11 165	1.017	.761	44.1	22.6	38 600	67 190	.021	"	"	"	Keystone Bridge Wks.
second half.....	7	1 1/2	376.57	.294	7.00	1.37	Area = 7.15	.....	34.6	42.1	19.3	34 060	62 349	"	11 169	.990	.600	16.3	31.5	41 000	68 010	.021	"	"	"	"
Bar 54.97 ft. long cut in two pieces, first half.....	9	1	386.14	.288	8.86	1.23	6.92	0.92	41.6	64.0	12.1	33 580	66 390	"	70 919	1.391	.191	38.1	26.0	36 710	68 480	.019	"	"	"	Phoenix Bridge Co.
second half.....	7	1 1/2	408.54	.430	7.08	1.04	6.82	0.80	38.9	42.9	19.8	35 870	67 520	"	11 169	.590	.590	42.5	35.3	41 890	65 110	.019	"	"	"	"
Bar 54.97 ft. long cut in two pieces, first half.....	10	2 1/2	480.46	.420	10.02	2.32	7.50	1.07	20.4	53.9	20.4	29 700	56 390	"	10 980	1.644	.530	40.1	47.7	37 810	68 720	.019	"	"	"	"
second half.....	10	2 1/2	466.49	.420	10.08	2.36	7.30	1.01	20.3	46.6	11.1	30 060	60 780	"	10 980	1.644	.530	40.1	47.7	37 810	68 720	.019	"	"	"	"
Bar 54.97 ft. long cut in two pieces, first half.....	10	2 1/2	496.46	.420	10.09	1.72	7.43	1.06	24.3	54.3	19.0	30 690	56 170	"	2 166	1.363	.600	53.3	28.7	40 860	65 230	.011	"	"	"	"
second half.....	10	2 1/2	379.44	.420	10.06	2.00	7.33	1.84	44.2	44.1	18.5	28 440	54 470	"	15 154	1.452	.718	59.6	31.2	34 640	62 470	.018	"	"	"	"
Bar 54.97 ft. long cut in two pieces, not reannealed } first half.....	9	3 1/2	291.58	.232	11.04	2.62	7.45	2.02	37.7	31.8	11.6	32 180	59 270	"	9 912	1.117	.754	59.1	27.0	40 590	66 010	.038	"	"	"	Union Bridge Co.
After forging new heads..... } second half.....	10	2 1/2	323.04	.232	11.04	2.62	7.45	2.02	37.7	31.8	11.6	32 180	59 270	Body in grip marks.	"	"	"	"	"	"	"	"	"	"	"	
Second half of above reheated and reannealed.....	10	2 1/2	323.04	.232	11.04	2.62	7.45	2.02	37.7	31.8	11.6	32 180	59 270													

* Results from highest strain to which bar was subjected

† Combined results of two tests.

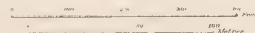




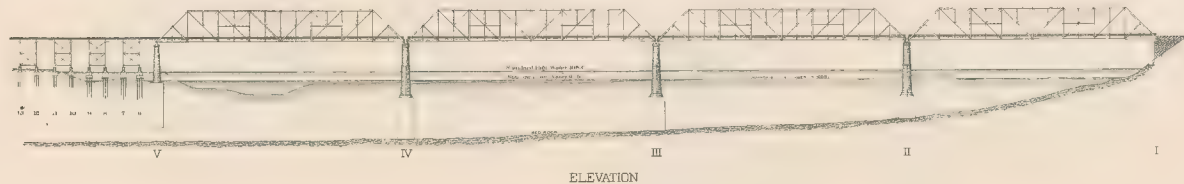
ST. L. & N. W. R. R. BELLEFONTAINE BRIDGE

General Elevation, Plan and Profile.

Scale



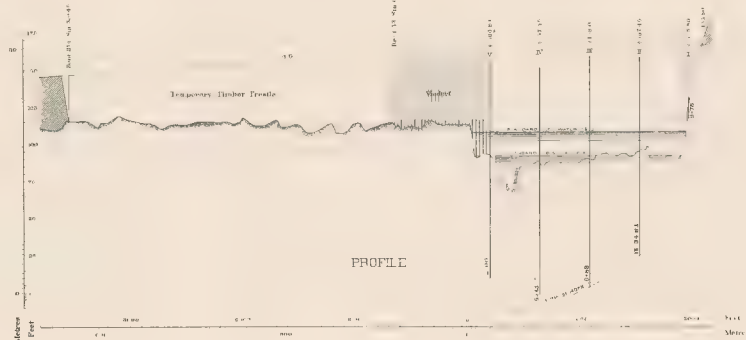
*See Notes
to Plan*



ELEVATION



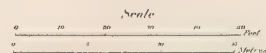
PLAN



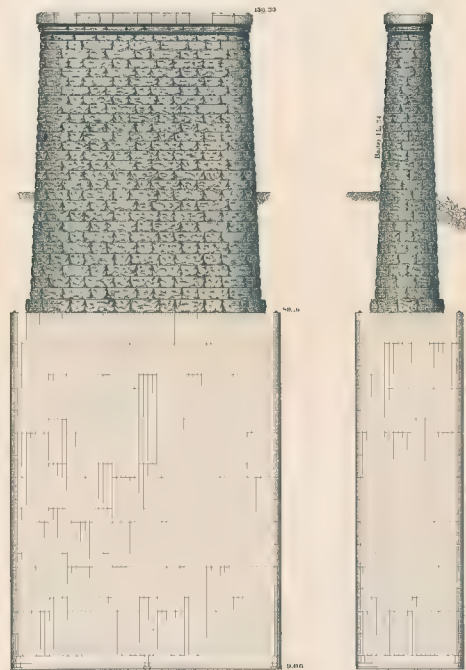
PROFILE



STURGES & NARR BELLEFONTAINE BRIDGE *Piers and V.*

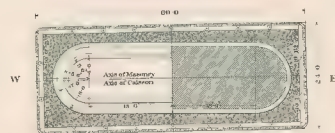


PIER V

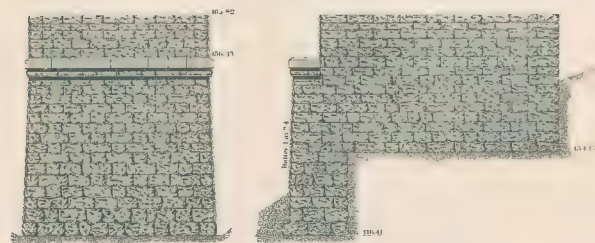


Side Elevation
South.

End Elevation.
West.

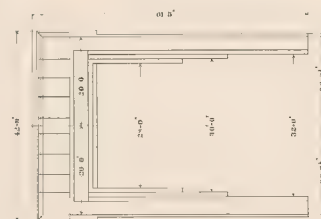


PIER I Abutment



Front Elevation

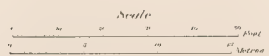
Side Elevation.
West.



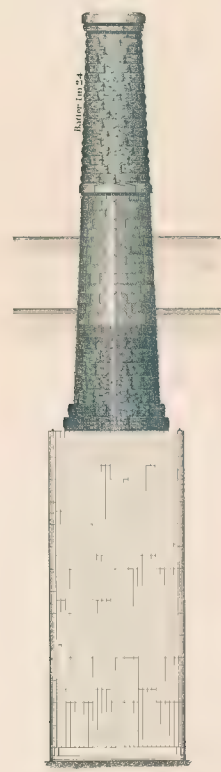


BELLEFONTAINE BRIDGE

Pier IV. Pier II similar.



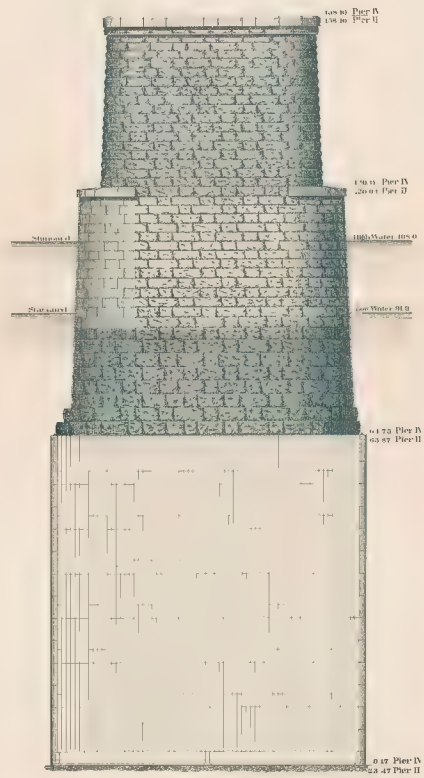
C. S. Norman
Architect



End Elevation.
West



Plan.

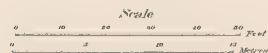


Side Elevation.
South

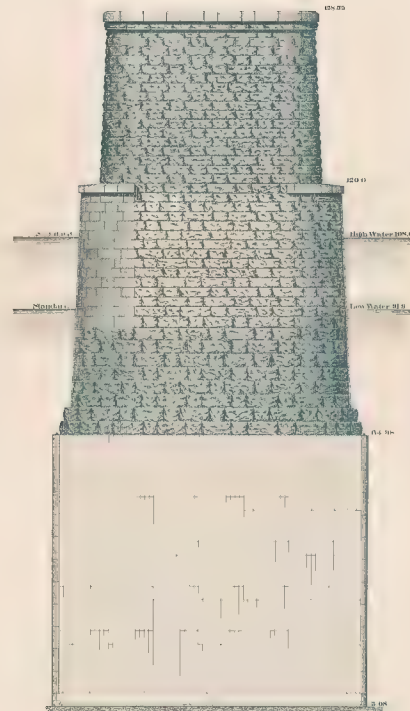
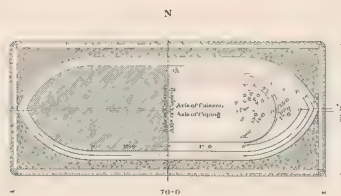
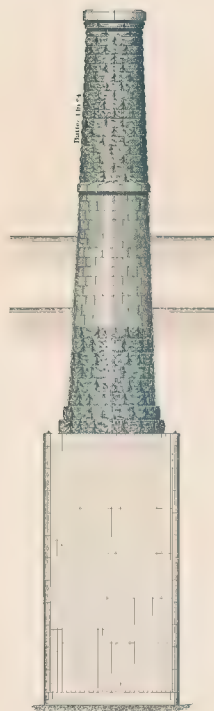


STY & J. P. 5 BELLEFONTAINE BRIDGE

Pier III.



*G. S. Housen
C. E. G.*



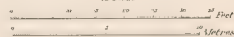


ST. L. & N.W.R.R. BELLEFONTAINE BRIDGE

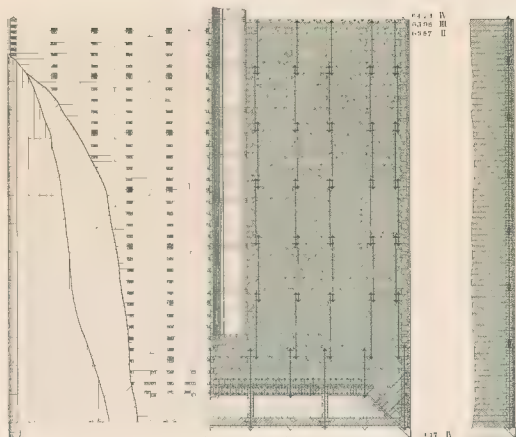
Caissons.

*L. S. Pearson
Ch. Engr.*

Scale



CAISSON IV
If and III similar.



Side Elevation

Section at AB

Section at EF

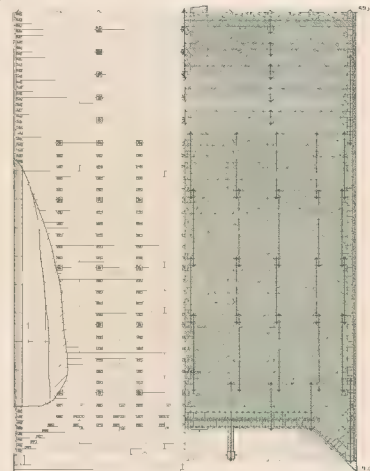


End Elevation. Section at CD



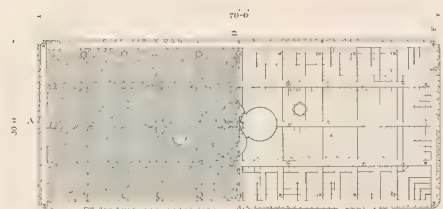
End Elevation. Section at CD
Caisson V

CAISSON V



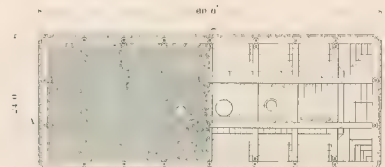
Side Elevation

Section at AB



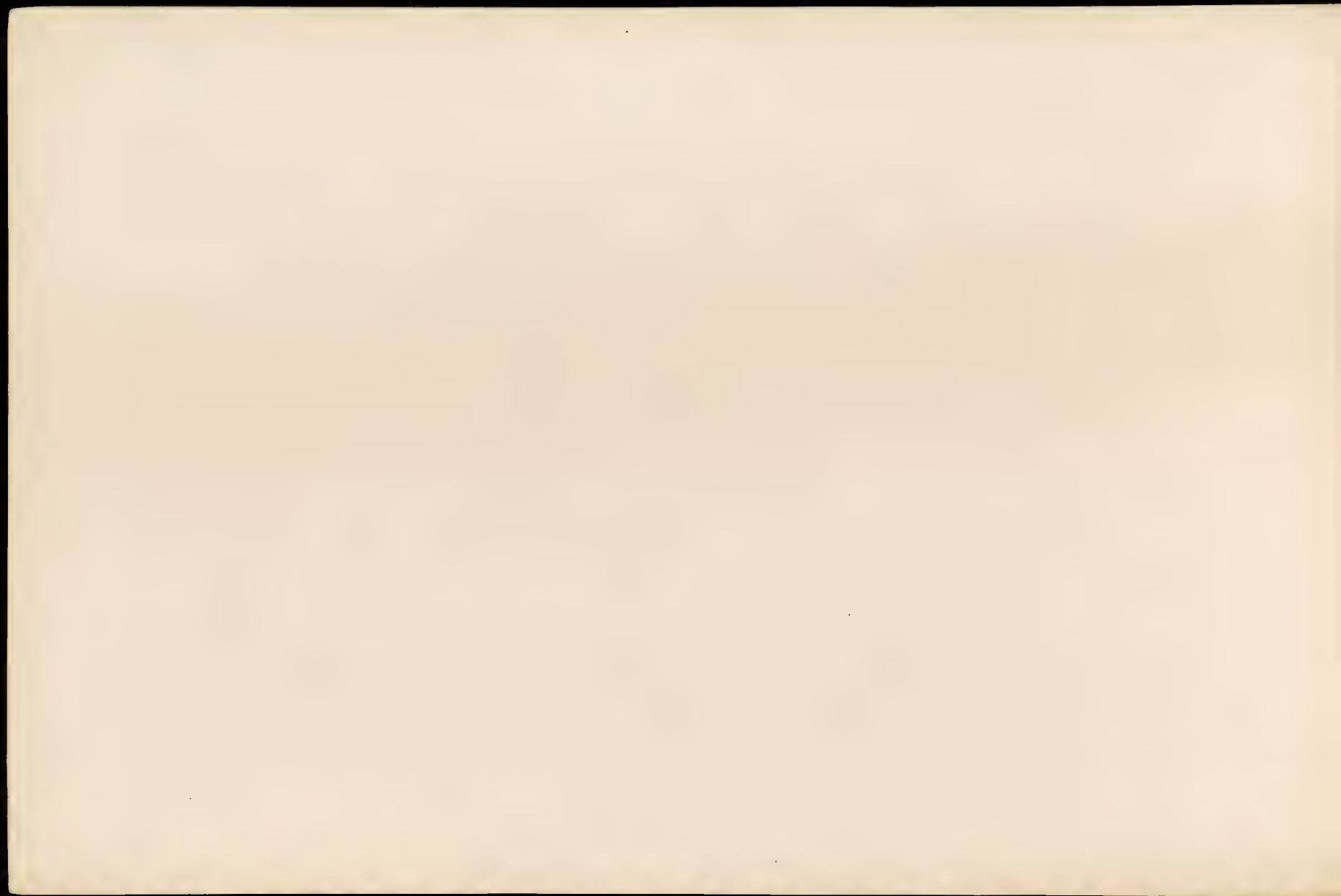
Plan

Plan, Concrete removed



Plan

Plan, Concrete removed



SILK & NW R.R.
BELLEFONTAINE BRIDGE
 Diagram showing rate of progress in sinking caissons.

*L. S. Mason
 & Co.*

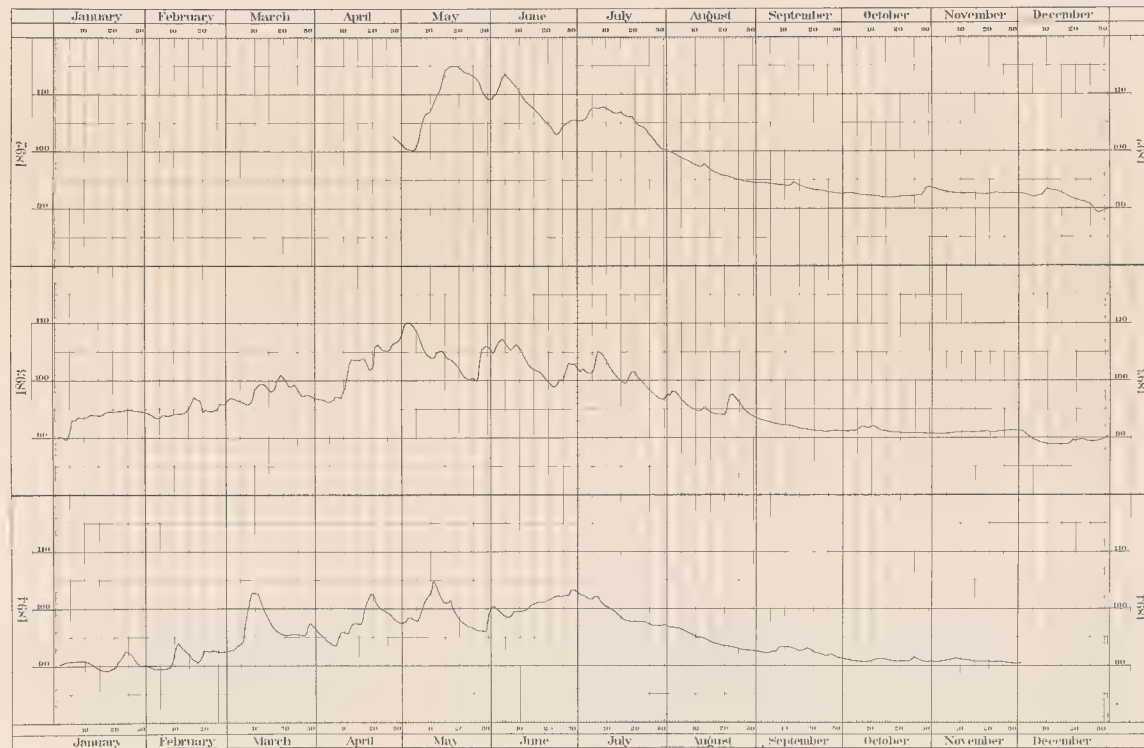


Datum is 100 feet below St. Louis City Directrix.



ST. L. & N. W. R. R.
BELLEFONTAINE BRIDGE
Water Gauge Record.

*L. S. Henson
Ch. Eng.*



Bottom is 100 feet below St. Louis City Street level
or 312.731 feet above mean tide at Bland

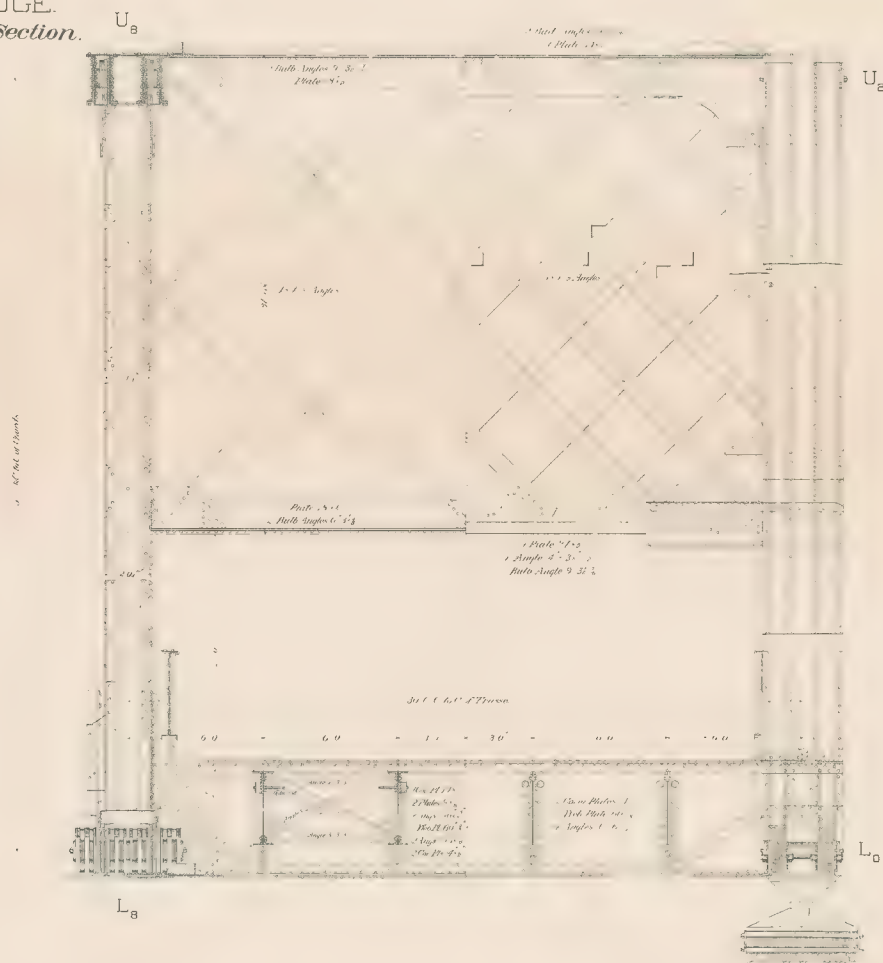


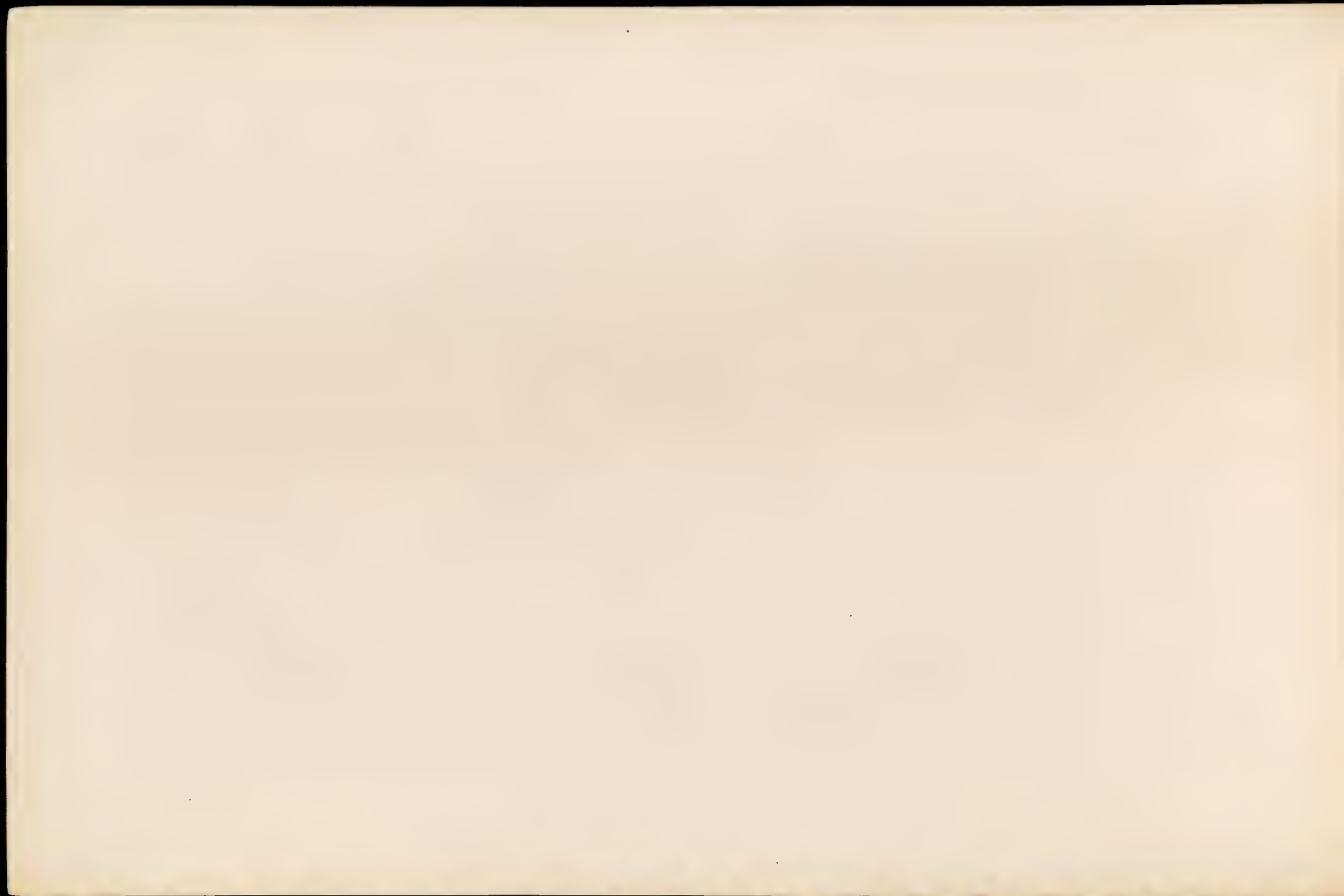


ST. L. K. & N. W. R. R.
BELLEFONTAINE BRIDGE.
440'-0" Span, End Elevation and Section.



W. D. Newton
writing.

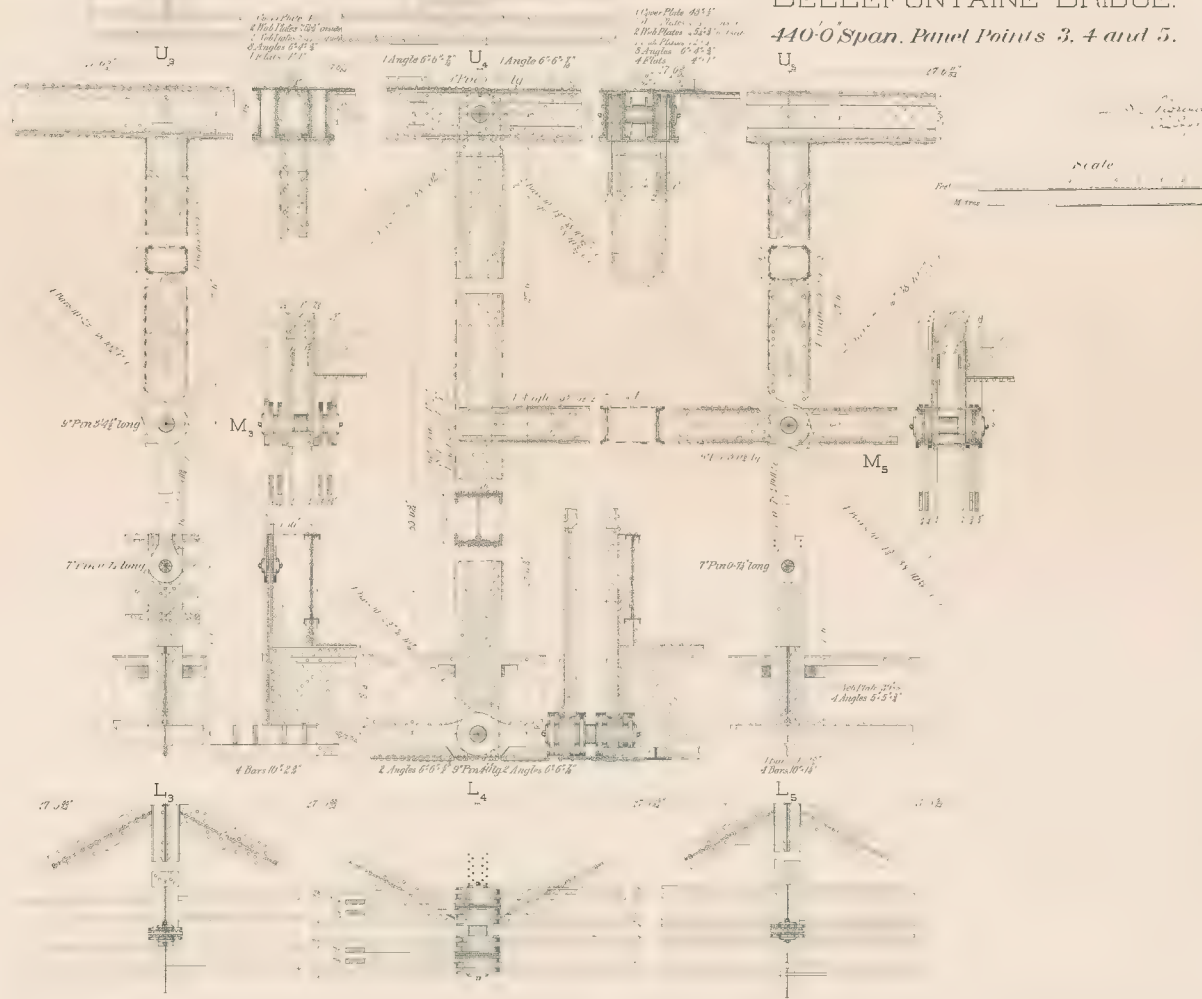






T. R. & A. F. F.
BELLEFONTAINE BRIDGE.

440'-0" Span, Panel Points 3, 4 and 5.





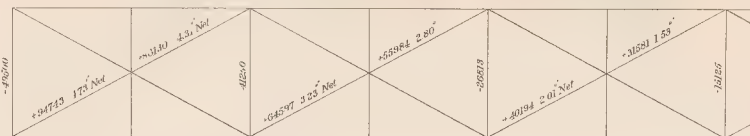
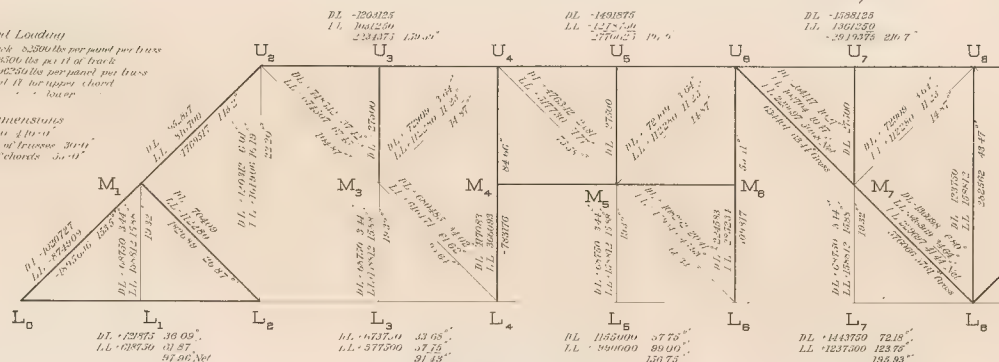


ST. K. & N. W. R. R. BELLEFONTAINE BRIDGE 440'-0" Span. Strain Sheet.

G. S. Davis
at *St. Louis*

Assumed Loading
Live Load - 2000 lbs per ft of track, 22000 lbs per panel per truss
Dead Load - 2000 lbs per ft of track, 22000 lbs per panel per truss
Wind Pressure - 20 lbs per sq ft of projected area
Wind Pressure - 20 lbs per sq ft of projected area

General Dimensions
8 Panels of 55 ft 0" each
Radius of 1/2 c. of truss 300 ft
Depth of face of chords 30 ft



UPPER LATERAL BRACING.



LOWER LATERAL BRACING.

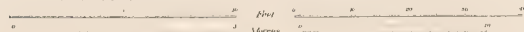


BELLEFONTAINE BRIDGE

Viaduct Foundations.

Scale of Piers G-31

Scale of Pier 32

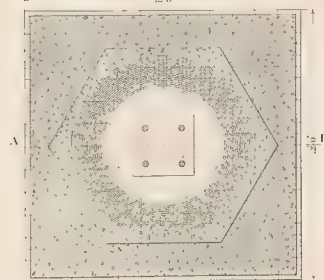


*L. S. Nason
Arch.*

Piers G-31

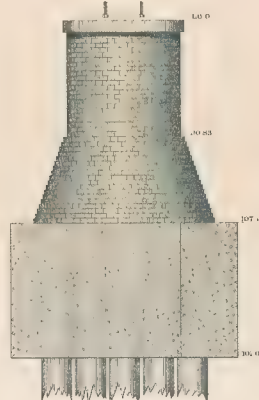


Elevation Section at AB

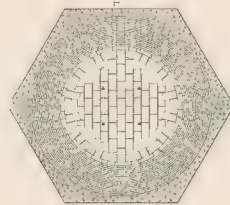


Plan

Piers 10-31

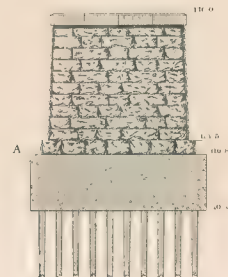


Elevation



Plan under cap

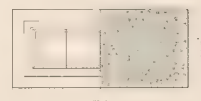
Pier 32



Side Elevation



End Elevation



Plan

Plan at A





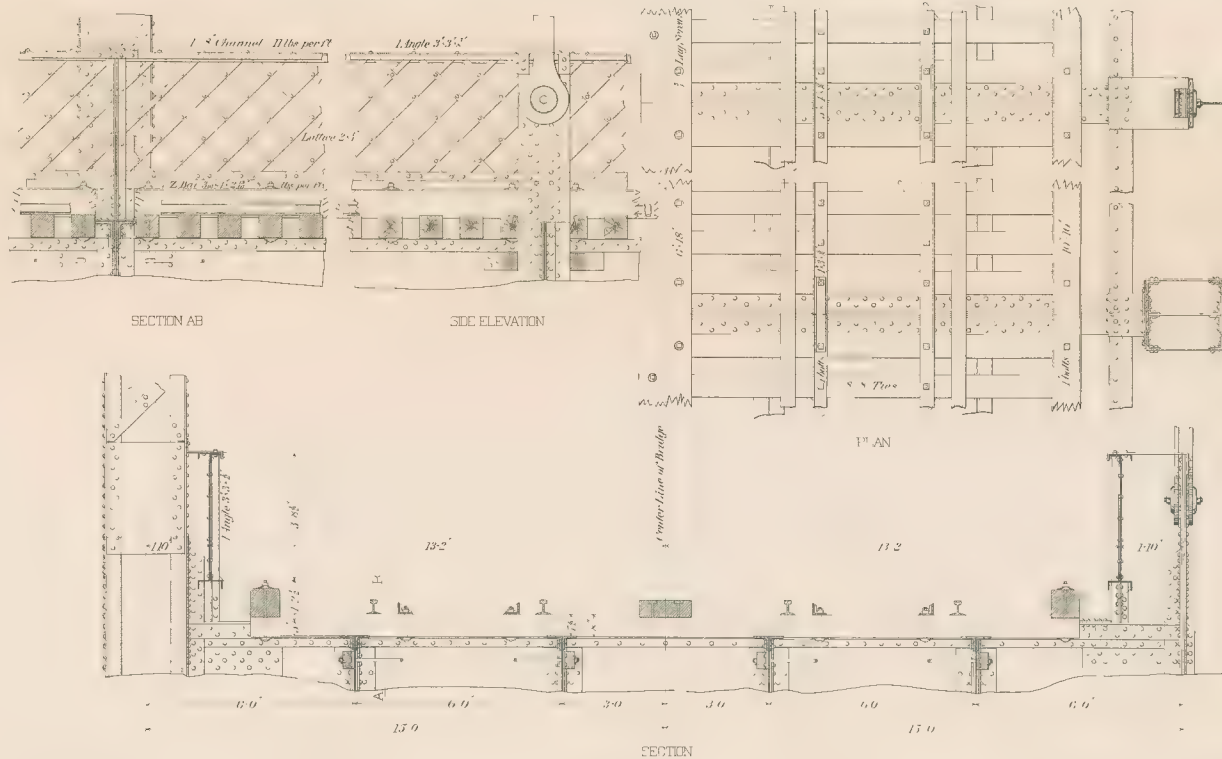
GENERAL PLAN BELLEFONTAINE BRIDGE

Floor:

Scale



L. S. Housen.
C. E. G.

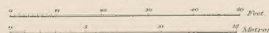




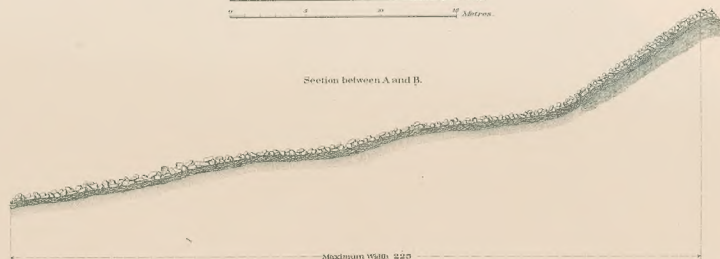
ST. L. & N. W. R. R.
BELLEFONTAINE BRIDGE
Shore Protection.

*L. S. Mendenhall
A. E. G.*

Section

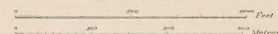


Section between A and B.

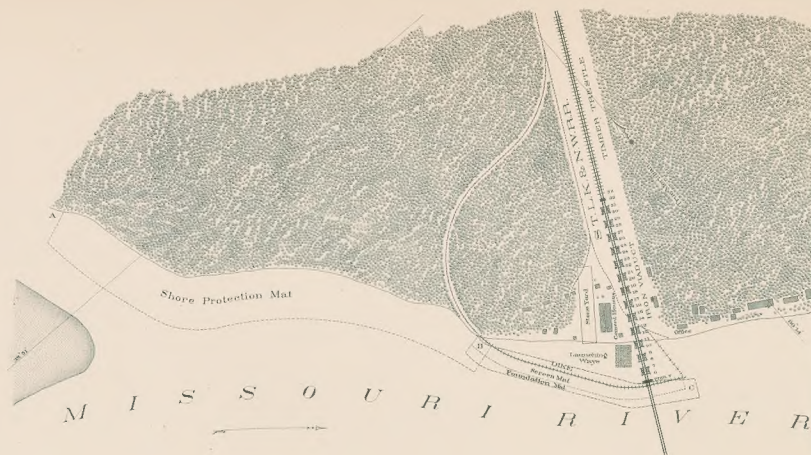
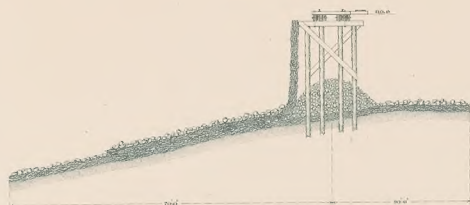


Maximum Width 125

Scale of Plan



Section between B and C. Dike.



91-B12948



